NAVAL POSTGRADUATE SCHOOL
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THESIS

DESIGN OF AN EVALUATION SYSTEM TO MEASURE PERFORMANCE DEGRADATION DUE TO CONTINUOUS OPERATIONS

by

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March, 1984

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Design of an Evaluation System to Measure Performance Degradation Due to Continuous Operations

by

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ABSTRACT

This paper establishes guidelines for an evaluation system designed to measure performance degradation due to continuous operations for battalion-sized units of the United States Army. It serves to initiate direction for the evaluation system, provides the framework on how to accomplish the necessary data measurements for such an evaluation, and enumerates the performance indicators to be measured. Techniques to analyze different types of data are provided, along with examples of the use of those techniques. A discussion of the uses of the analysis results is also presented.

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The increasing complexity of military tactics and equipment is placing major emphasis on evaluation of human performance as an integral part of the man-machine system. Technological advances result in new military equipment being developed for the Army to meet the anticipated requirements of the modern battlefield. Some of these advances will allow continuous operations without resupply or maintenance. The expanded equipment capabilities will place increased demands on the soldiers who will operate the equipment. [Ref. 1: p. 3]

Mobility and high tempo of combat operations is one of the seven principles of tactical doctrine followed by the Soviet Union's ground forces. The requirement of this principle, basically, is to achieve and sustain rapid movement of combat forces. The principle includes the battlefield mobility of maneuver forces, the maneuverability of fire support, and the mobility of logistics elements to sustain operations. A high tempo relates to the relentless execution of an operation without pause. The Soviets feel it is critical to keep the enemy off balance and under constant pressure, thereby preventing the enemy from forming an effective defense [Ref. 2: pp. 1-6].

The improvements in equipment, coupled with the doctrine of Warsaw Pact nations to conduct protracted operations, indicate that today's soldier is more likely to participate in sustained operations than ever before.

The U.S. Army, through several of its research and development agencies, has used and will continue to use combat simulations as a means for planning, testing, and evaluating weapons systems, tactics, and strategies at all organizational levels. Included as part of combat models and simulations should be data that takes into account performance degradation of a unit and its members that occurs when they are subjected to periods of continuous operations. Such data resulting from research into performance degradation through actual evaluations of performance in the field do not exist. In situations where planners require information on human performance, they must rely almost entirely on judgments based on past experience. These judgments become more invalid as tactics, strategies, and equipment change and become more sophisticated. [Ref. 3: pp. 1-2]

A. EVALUATION SYSTEM

In order to determine what effect continuous operations have on a unit's performance, a controlled, realistic, and accurate evaluation system is required. The ultimate objective of such a system is to provide measured data

giving insight to how much, if any, a unit's performance is degraded due to sustained operations. These data would provide a means to investigate the effectiveness of units over a prolonged period of time and allow planning considerations, adjustments, and compensations for degraded performance to be made so that improved effectiveness may be obtained from units subjected to sustained combat conditions. Such data would add the realism needed in current combat simulation models. This paper establishes guidelines for an evaluation system to measure performance degradation over a period of continuous operations and to provide the needed data.

The setting for such an evaluation requires a field environment rather than a laboratory experiment. A laboratory experiment is normally not appropriate for an evaluation of this type for the following reasons:

a) only a few independent variables are selected and many important interactions may be excluded.

b) the character of the variables is often changed in the laboratory.

c) experimental conditions are so well controlled that significant differences found in the laboratory are later found to be of no practical importance in the field.

d) the methods used to present variables are unrealistic.

e) criteria are chosen for convenience rather than relevance. [Ref. 3: p. 3]

A field environment, such as the National Training Center at Fort Irwin, California would serve as an ideal location for

evaluation of sustained operations. The suitability of this environment is discussed in Chapter IV. The evaluation system is designed to consider battalion size units, specifically considering four levels within the battalion:

-- Battalion command and control
-- Rifle companies
-- Special platoons
-- Individual soldiers

B. OBJECTIVES

Through this design the following objectives are established for the evaluation system:

-- To measure the amount of unit and individual degradations in performance during a period of continuous operations from that of baseline conditions.

-- To establish a realistic data base for use in existing models and for the construction of more accurate combat models which can support developments in tactics, strategy, and equipment.

-- To obtain data on the effectiveness of the internal organization of a combined arms force while operating for sustained periods of time.

-- To obtain data which shows the impact of different training techniques to enhance the ability of a combined arms force to conduct its missions over a period of continuous operations. [Ref. 4: p. 1-4]

A well designed evaluation and a well executed effort to collect the necessary data could provide answers to a myriad of questions, in addition to meeting the stated objectives. Through use of the data in combat simulations versus expensive, hard to control, and sometimes impractical field tests, such things as deficiencies in doctrine, training,

materiel, and organization may be identified. Being able to conduct these simulations using reliable data obtained through this design may preclude deficiencies not being recognized until it is time to employ the system in combat. Questions such as the optimal time to relieve a unit of front line duty, time to commit reserve units, percentage of strength at which a unit can operate and still be effective, priority of reinforcements, etc., may all be addressed with some credibility. Further, once degradation in performance is detected, efforts may be directed to design systems, tactics, or strategies to compensate for that degradation. As such, the end result of the evaluation system should be data that is suitable and adaptable to combat models that are utilized for investigative purposes.

Initially the focus on data generation and collection will be approached as if virtually no constraints exist on the amount or type of data to be collected. However it is realized that there will be constraints in terms of manpower, time, and equipment to collect the data when such a system is implemented. At that point, the data to be collected may be tailored based on existing constraints. Care must be taken to balance the tradeoffs between reducing the amount of data to be collected and the usefulness of the data once it is gathered. It must be insured that sufficient data is assembled so that reliable conclusions may be drawn from data analysis. A significant portion of

this research effort involved the determination of performance indicators, criteria, and missions that are realistic and consistent with the objectives of this evaluation system. These factors are described in Chapter III and are fully documented in Appendices A through D (each appendix describing one level of the battalion to be evaluated).

The design concepts of the evaluation system, presented in Chapter II, describe the evaluation procedures to include the type of data to be collected, the environment for data collection, and methods to measure performance and performance degradation. Examples of the types of data that are to be collected are given in Chapter III, demonstrating the different levels of performance indicators that are examined throughout the evaluation. Chapter IV describes the resources that exist at the National Training Center (NTC) at Fort Irwin, California and their suitability to the suggested evaluation system. Implementing an evaluation system such as proposed in this paper will require a dedication by the Army to the stated objectives. Manpower for evaluation control, data collection and analysis, as well as training areas, equipment and numerous other resources are needed if an evaluation of this type is to be successful.

Procedures for the statistical evaluation of the data collected under conditions of sustained and normal

operations are discussed in Chapter V. These procedures address appropriate methodologies for evaluating whether performance differences occurred and, if so, the magnitude of the performance differences. The procedures are developed for both quantitative (ratio scale) data and subjective (interval scale) data. These performance differences are addressed at the individual performance indicator level, as well as the aggregated levels of criteria and missions. Finally the utilizations of the evaluation results for combat models and training audit trails are described in Chapter VI.

The performance indicators, and their aggregation into criteria and missions, are presented in appendices A through D as previously discussed. A sample scenario for implementation of the evaluation system is given in Appendix E. Specific statistical procedures required for data analysis described in Chapter V are given in Appendix F.

In summary, the proposed evaluation system is designed to provide a methodology to investigate differences in performance between normal and continuous operations in a field environment. This paper indicates the steps and procedures required to realize such a system.

II. DESIGN CONCEPTS OF THE EVALUATION SYSTEM

In order to develop the design of an evaluation system for assessing performance differences of combat units in an Army Test and Evaluation Program (ARTEP)/NTC environment, the following issues must be resolved. [Ref. 5: p. 6]

A. PERFORMANCE INDICATORS

Before considering evaluation methods, the performance indicators for evaluation must be developed. These indicators will provide a means to measure the overall objectives of the evaluation and must be relevant to the purpose of the evaluation. In order to accomplish this, the performance indicators selected for evaluation are divided into four levels. The first level is related to the battalion commander, his staff, and some of the key assets available to him, noted as the battalion command and control level. This level is subdivided into missions, which are further subdivided into criteria, which in turn are subdivided into performance indicators. For example, at the battalion command and control level the mission of the S-4 (logistics officer) is to provide logistics support. The criteria that make up this mission are:

-- Ability to Provide Essential Supplies
-- Ability to Provide Transportation
-- Ability to Provide Messing Operations

These criteria are evaluated using performance indicators. For the criterion, Ability to Provide Essential Supplies, the performance indicators are:

-- percent request for supplies not met
-- number of required and requested logistics reports not submitted
-- percent supply requests not delivered on time
-- proportion of required and requested logistics reports not delivered on time [Ref. 4: p. 5-45]

Performance indicators that relate to command and control were selected to investigate the possible degradation of performance at the battalion command level in continuous operations. It was felt that degradation at this level would lead to degraded performance at lower echelons and therefore the need to evaluate these performance indicators was deemed critical. The complete list of performance indicators for battalion command level are specified in Appendix A.

The second level selected for evaluation is the rifle company. This level is also divided into missions. The missions to be evaluated for the rifle companies are:

-- Movement to Contact
-- Hasty Attack
-- Deliberate Night Attack
-- Delay
-- Deliberate Defense

For each mission undertaken by a company, there are criteria specified and these criteria are subdivided into performance indicators. Using the mission of Deliberate Defense as an example, the criteria are:

-- Preparation of Organization and Plan
-- Occupation of Fighting/Battle Position
-- Establish Security
-- Prepare Fighting Positions
-- Defend as Opposing Force Approaches Positions
-- Conduct a Counterattack
-- Consolidation and Reorganization
-- Ability to Acquire and Destroy Targets
-- Ability to Seize and Hold Terrain [Ref. 6: pp. 7-4-1 - 7-4-7]

These criteria are evaluated using the specified performance indicators. For the criterion, Establish Security, the performance indicators are the assessment of:

-- use of observation posts on likely avenues of approach
-- plan and use of patrols
-- use of sentries
-- limited use of radio
-- use of early warning devices on likely avenues of approach
-- use of challenge and password
-- alertness along perimeter

The missions and subsequent criteria and performance indicators are similar to those that are undertaken as part of a normal ARTEP evaluation and are discussed in a later section of this chapter. The complete list of performance indicators for this level are defined in Appendix B.

The third level to be evaluated is the specialized platoons organic to the infantry battalion, namely, the anti-tank platoon, the scout platoon, and the 107mm heavy mortar platoon. The importance of these platoons to the battalion's operation is critical and deserving of special consideration. The platoons each have their own missions. The scout platoon's missions are to:

-- Conduct a Screen
-- Conduct a Zone Reconnaissance
-- Conduct an Area Reconnaissance
-- Conduct a Route Reconnaissance

The anti-tank and heavy mortar platoons' missions are to provide anti-tank fire support and indirect fire support, respectively. As in the case of the rifle companies, the special platoons' missions are divided into criteria which are further divided into performance indicators. For the scout platoon's mission of a Zone Reconnaissance, the criteria are:

-- Plan and Prepare a Zone Reconnaissance
-- Deploy Teams
-- Locate Opposing Force
-- Develop the Situation
-- Collection of Terrain Specific Information
-- Occupy an Assembly Area [Ref. 6: pp. 8-36-1 - 8-39-4]

These criteria are then evaluated using the performance indicators for each. For the criterion, Collection of Terrain Specific Information, the performance indicators are:

-- given opposing force has withdrawn, assessment of obtaining and reporting information on:

    -- condition of road network in zone
    -- cross country trafficability
    -- obstacles and removal when possible
    -- bypasses around obstacles
    -- fords and water entry/exit points on water obstacles
    -- other information required by task force order

-- assessment of reports given by quickest and most secure means available during reconnaissance

The complete list of performance indicators for this level is given in Appendix C.

The fourth level is that which pertains to the individual soldier. As a means to measure performance and performance degradation of the soldier, performance indicators associated with the common tasks a soldier is expected to perform were selected for the individual rifleman, for the soldier as a member of one of the special platoons, and the soldier with a specific job such as a machine gunner, radiotelephone operator, etc. For example, there are tasks that every soldier is expected to be able to perform, no matter what his primary duty position might be. These tasks are grouped together as:

- -- First Aid Tasks
- -- Nuclear, Biological, and Chemical Tasks
- -- Basic Individual Techniques
- -- Camoflauge, Cover and Concealment Tasks
- -- Security and Intelligence Tasks
- -- Land Navigation Tasks
- -- Night Vision Device Tasks
- -- M16A1 Rifle Tasks
- -- Light Anti-Tank Weapon (LAW) Tasks
- -- Hand Grenade Tasks
- -- Mine Tasks [Ref. 7: pp. 2-1 - 3-267]

The first aid tasks consist of:

- -- Ability to perform mouth to mouth resuscitation and external heart massage
- -- Ability to stop bleeding (arm or leg wound)
- -- Ability to identify signs of and treat for shock
- -- Ability to splint a fracture
- -- Ability to apply first aid measures for burns
- -- Ability to apply first aid measures for heat injuries
- -- Ability to apply first aid measures for wet or cold injuries

The individuals with a specific job such as the M203 grenadier have additional tasks such as:

-- Ability to perform operator maintenance on M203 grenade launcher and ammunition
-- Ability to load, unload, and clear the M203
-- Ability to zero an M203
-- Ability to engage targets with an M203 and apply immediate action to reduce a stoppage
-- Ability to use limited visibility firing techniques with the M203

The tasks for individual evaluation are given in Appendix D.

B. THE SCENARIO

For purposes of this evaluation, the measurement of performance in an NTC type environment is proposed to be the appropriate way of conducting the evaluation due to the lack of realism and validity currently available from other sources. Even though problems of standardization, consistency, and control exist in a field environment, it is felt that the effort to minimize potential distractors is necessary, rather than accepting higher levels of artificiality present in combat models. Conduct of the evaluation in the field, such as in an NTC type environment, will produce credible results if properly structured and executed. A well written scenario will assist in giving the evaluation the needed structure.

In order to evaluate the performance indicators as described above, a scenario has been developed through which the actual evaluation of performance (as measured by the designated variables) will take place. The scenario will provide two capabilities to meet the objectives of this evaluation. First, it will outline a plan of continuous

operations so that the effects on performance may be investigated. Second, it will provide a logical sequence of events during which the performance indicators to be evaluated may be measured. The units to be evaluated will be expected to perform the following missions in accordance with the proposed schedule.

Occupation of an Assembly Area	0700	DAY 1
Conduct a Movement to Contact	1200-1600	DAY 1
Conduct a Hasty Attack	1600	DAY 1
Conduct a Deliberate Night Attack	0300	DAY 2
Conduct a Delay (under enemy pressure)	1500-1800	DAY 2
Conduct a Deliberate Delay	from completion of delay (DAY 2) -0800	DAY 4
Conduct Counterattack	0800-1100	DAY 4

The units will be evaluated for a period of seventy-six hours. During that period the units will proceed from one mission to another in a sequence that a battalion might expect to receive its missions in combat, keeping the unit continuously deployed, yet with sufficient time to plan and conduct its operations. Although the unit is in the deliberate defense for approximately thirty-eight hours, it is felt the variety of tasks that must be performed and the physical requirements, such as constructing battle positions, providing security, and executing leaders' tasks are more than sufficiently demanding to keep the units occupied and stressed. The time schedule does not explicitly show such activities as consolidation and reorganization after the attacks, which are required and

listed in the appendices as performance indicators to be measured. A complete scenario to support the time schedule has been written to provide all necessary details and will be given initially in the form of an operations order (OPORD) to the evaluated unit. Orders for a delay, deliberate defense, and other subsequent operations will be given as the evaluation continues in the form of fragmentary orders (FRAGO). These orders are issued in a manner that provides realism, continuity, and control. As such, the scenario satisfies the requirements of providing continuous operations and allows the measurement of the performance indicators listed in Appendices A through D. A complete sample scenario is provided in Appendix E.

C. PERFORMANCE MEASUREMENT TECHNIQUES

The performance indicators to be measured have been identified and the environment and scenario in which to measure them have been determined. The next major task is to determine how to actually measure the performance indicators. To accomplish this, three factors must be taken into account:

-- standards by which to measure performance
-- who will do the evaluating
-- means of control over evaluation

The standards by which to measure performance, whether taken from a field manual, ARTEP manual, soldier's manual, or decided upon by a group of experienced military judges, must

be realistic, consistent with existing doctrine, and made known to the evaluated unit. The units must have sufficient time prior to the evaluation period to train to achieve those standards. The assigned missions, criteria, and their associated performance indicators as given in the appendices are a result of the author's refinement of composite lists from several documents (Refs: 4,6,7,8, and 15). In addition, research into other experiments conducted by agencies such as The Army Research Institute, The Combat Developments and Experimentation Command at Fort Ord, California, ORI Inc., in Monterey, California, and The Human Resources Research Organization, and the author's personal experience as an infantry officer were used to develop the appendices.

Some of the performance indicators require evaluator's judgment and thereby introduce a problem of possible inconsistency from one evaluator to another. For example, what one evaluator may deem as sufficient concentration of combat power to overwhelm and destroy the opposing force may not be the same for another evaluator and may result in different ratings. An example of the quantitative versus the subjective evaluations for each level of performance is included in Chapter III. Methods of resolving such problems as differences in evaluator's judgments are discussed in Chapter V. The subjectivity of the evaluations is related to the individuals involved. Consistency between evaluators is extremely important, both to the units being evaluated and

to the data collection effort. To attain this consistency, a well trained, professional, cadre of evaluators such as those in the Operations Group at the NTC, would be ideal. These evaluators must be aware of the impact which their subjective evaluations have on the overall objective and must be conscious of the importance of consistency. These factors are necessary to produce a statistically reliable evaluation.

For the most part control over the evaluation will result from a well written scenario and the implementation of that scenario by the evaluators and controllers. This will be part of the training which the evaluators/controllers will receive. Situations might arise when the unit is unable to complete or start a mission by a specified time. In such a case the evaluators and controllers must respond in order to make the units continue the operations in an appropriate manner, such as by issuing a fragmentary order. Whatever the means, they must maintain positive control over the situation so that the units perform the missions designated, the evaluators measure the appropriate performance indicators, and the needed data is collected. Control is also extended to include the opposing forces by insuring that they follow the scenario and are responsive through their chain of command to the evaluators/controllers. It will be shown in Chapter IV how the

evaluators/controllers are assisted in controlling the evaluation and even in making evaluation judgments by the use of instrumentation and other means at the NTC.

D. EXAMINING PERFORMANCE FOR DEGRADATION

To examine performance degradations that result from continuous operations, baseline data must be compiled on the same performance indicators but without the effects of continuous operations. This entails subjecting units to the same scenario and measuring the same performance indicators, but doing it one mission at a time in an effort to eliminate the effects of continuous operations. The methodology by which the baseline data are compared to the data from continuous operations is discussed in Chapter V.

Data from the continuous operations will be compared to the baseline data and examined for any significant differences. The result of this analysis will provide insight into the differences between performance factors in continuous operations versus baseline conditions. Data will be maintained to facilitate analyzing individual units, units as groups, improvement in training techniques, effectiveness of new weapons systems, etc. The better the design, planning, and execution of the evaluation, the greater the chances that the differences in continuous operations performance and baseline performance can be determined from analysis of the data.

III. PERFORMANCE MEASUREMENTS

As previously discussed, problems may arise concerning the subjective evaluations. In order to effectively conduct the analysis, the differences between a quantitative and subjective evaluation must first be made evident. To demonstrate this difference, examples of actual performance indicators to be measured will be used. As seen in Appendices A through D, each performance indicator is followed by either a (Q) or an (S) to signify whether that indicator is quantitative or subjective in nature. For each indicator that is quantitative in nature, the evaluator simply records the observed result. There is no latitude for the evaluator to make a judgment. In some cases the evaluation may merely involve a tally such as the munitions expended by number and type, or the percentage of calls for fire support acknowledged. The evaluator is assisted in this task by a sophisticated system of data collection devices discussed in more detail in Chapter IV.

In the case of the subjective rating, the evaluation method is not as clearly defined. For example, a performance indicator such as the assessment of the route of advance selected is not as definite as counting the number of reports submitted. The rating scheme for subjective evaluations and how to make use of them is discussed in

Chapter V. It can be seen that this is an area that requires a well trained, professional cadre of evaluators.

A. LEVELS OF PERFORMANCE INDICATORS

The following are examples of performance indicators to be measured at each level, demonstrating the difference in quantitative and subjective type indicators within the various missions and criteria. At the command and control level would be the S-3 (the operations officer) and his staff for evaluation in the operations area. A criterion, as found in Appendix A, page 71 , would be "Ability to Support the Commander During Operations." The quantitative performance indicators to be measured are:

- -- percentage of required or requested reports not submitted (Q)
- -- percentage of required or requested reports not submitted on time (Q)
- -- percentage of required or requested reports submitted that are not accurate (Q) [Ref. 4: p. 5-5]

At the company level, one of the criteria for the Hasty Attack mission, as found in Appendix B, page 77 , is to "Conduct a Hasty Attack". The subjective performance indicators to be measured for this criterion are:

- -- assessment of ability to eliminate opposing force (S)
- -- assessment of ability to determine opposing force strength and disposition (S)
- -- if resistance is assessed to be too great to overcome, assessment of request for assistance from higher headquarters (S)
- -- assessment of use of indirect fires (S)
- -- assessment of leader's FRAGO to accomplish required tasks (S)
- -- assessment of use of cover and concealment (S)
- -- assessment of use of other supporting fires (S)

-- assessment of ability to consolidate, reorganize and prepare to continue attack once objective is taken (S)
-- situation reports (SITREP) submitted as necessary (S)
-- assessment of movement techniques (S) [Ref. 4: pp. 5-11 - 5-15]

At the platoon level, as part of the indirect fire support mission, several criteria are designated for evaluation similar to the following described in Appendix C, page 90 , "Engage an Area Target."

The quantitative performance indicators to be measured are:

-- Time it takes until platoon initiates fire for effect (FFE) once the target is identified (Q)
-- Distance FFE volleys are from the target area (Q) [Ref. 6: p. 8-41-4]

At the individual level the tasks are composed of performance indicators of a subjective nature. They will be rated in accordance with the system specified in Chapter V. For example, one of the performance indicators in the group of tasks for the Light Antitank Weapon (LAW) found in Appendix D, page 95 , is Ability to Prepare an M72A2 for Firing; Restore M72A2 LAW to Carrying Configuration.

B. EVALUATOR'S GUIDE FOR INDIVIDUAL LEVEL

An evaluator's guide is provided to standardize the grading at the individual level. Below is an example of such a guide for the performance indicator, Ability to Prepare an M72A2 for Firing.

1. Conducts prefire inspection.

    a. Checks seals to see if intact
    b. Checks tube for cracks, punctures, or crushing
    c. Checks safety handle to insure it is spring loaded

d. Checks data plate on launcher for the words "w/coupler"
e. Tells trainer whether LAW is usable or, if not, why it is unusable.

2. Prepares launcher for firing.

a. Removes sling assembly
b. Extends the LAW until it is locked in position
c. Places LAW on shoulder with front end of the LAW toward target
d. Checks backblast area before arming the LAW
e. Arms the LAW while keeping it on the shoulder

3. Restores launcher to carrying configuration.

a. Returns trigger handle to SAFE
b. Grasps launcher by rear sight housing and squeezed detent boot
c. Collapses launcher slightly
d. Moves hand from detent boot to front sight
e. Holds down front sight and collapses launcher until inner tube covers tip of front sight
f. Folds down rear sight and guides it under housing
g. Compresses launcher until travel is stopped by lip on front sight, presses front sight up with thumb and slowly compresses launcher over lip edge
h. Removes thumb from front sight and grasps housing
i. Closes launcher fully
j. Closes rear cover, insuring that the round lock fits through the slot in the cover
k. Replaces cover pull pin
l. Replaces front cover and holds in place
m. Replaces sling assembly by grasping both web straps of the sling assembly next to the hook springs and placing thumb on the rear cover above the hinge, exerts downward pressure with thumb and pulls up on the sling assembly until the hooks snap into position over the cover hinge [Ref. 8: p. 3-123]

The evaluator will use the above guide and rate the soldier from poor to superior. Normally these type tasks are scored on a Go, No-Go basis, but for the purposes of evaluating performance degradation the subjective rating scheme proposed in Chapter V is used.

In summary, this chapter indicates the diverse nature of the performance indicators, criteria, and missions which must be evaluated. They represent various levels of resolution requirements for their specification, in addition to the combination of quantitative and subjective evaluations. Before describing the techniques required to evaluate these complex interactions (Chapter V), the proposed environment for obtaining the needed data is described in the next chapter.

IV. THE NATIONAL TRAINING CENTER ENVIRONMENT

The suitability of the National Training Center (NTC) at Ft. Irwin, California, for this experiment is discussed in this chapter. A facility such as the NTC is a necessity if an experiment of this type is to be conducted with a high degree of realism and reliability. The objective of the NTC is to:

> "Provide a facility where heavy battalion task forces, controlling brigade headquarters, and supporting units can undergo essential combat arms training that cannot be accomplished at home stations due to physical limitations and prohibitive cost of providing a realistic training environment." [Ref. 9: p. 1]

Adhering to that objective, the NTC provides a realistic combat environment in which training for combat can be accomplished, as well as the evaluation of the units that undergo training. The evaluations are performed as an aid to training so that the units may discover their strengths and weaknesses and use the evaluation as a guide to follow-on training at their home stations. In some ways the means of evaluation by way of data gathering is very sophisticated, especially when compared to the home station ARTEPs administered and evaluated by sister units. The following is a brief overview of the data collection system at the NTC.

A. NATIONAL TRAINING CENTER INSTRUMENTATION

The instrumentation system for data collection at the NTC is The National Training Center Instrumentation System (NTC-IS). Data is generated and collected from live fire and force-on-force engagement exercises. The data is collected by instrumentation in the training area, observers and controllers (O/Cs), video recordings, and monitored radio nets. The NTC-IS is composed of three major subsystems: the Core Instrumentation Subsystem (CIS), the Range Monitoring and Control Subsystem (RMCS), and the Range Data Measurement Subsystem (RDMS). The RDMS provides real-time position location and engagement event data for all instrumented players. The RMCS includes automated sensors, video cameras, and O/C's for the purpose of monitoring and controlling activities within the training area. All data inputs go through the CIS which acts as a computer recording center and an operations center for Exercise Management and Control teams (EMC) and Training Analysis and Feedback teams (TAF).

The CIS is the central computer facility that provides all real-time data processing and interactive displays necessary to monitor, command, control, and evaluate the training throughout the exercise area. The RMCS is linked to the CIS through a visual, audio, and digital communications network that provides the means to monitor and control activities. The RDMS is also linked to the CIS

through a digital interface component which allows transformation of the data to the CIS in a usable form. The CIS processes and displays the data as necessary for analysis and evaluation. Personnel in the CIS can then control the exercise by transmitting messages to the RMCS, advising or aiding the O/C's in the control of the evaluations. The instrumentation utilized at the NTC includes the Multiple Integrated Laser Engagement System (MILES) for automated casualty assessment. MILES consists of varying types of eye-safe lasers which can be fitted to most direct fire weapon systems. Players (soldiers, tanks, armored personnel carriers, etc) are fitted with sensors which detect the strike of a laser beam. When a player is struck by a laser beam, that weapon system is rendered inoperative. [Ref. 10: pp. 27-53] Instrumentation also exists to record position location and event occurrences, such as weapons' firings and unit movements, for up to 500 players. [Ref. 11] The following are examples of how the system's instrumentation enhances an evaluation.

-- Position Location: every instrumented player has his location measured every thirty seconds via the RDMS and data files are maintained at the CIS. These files allow for calculations such as movement distances, movement rates, and ranges between players.

-- Training Area Observations: two large cameras positioned on mountains overlooking the exercise area and

six mobile video teams combine to provide video displays to the personnel in the CIS. Through communication links to the O/C on the ground, the personnel monitoring the displays can aid the O/C to reflect unit and individual movement techniques, use of cover and concealment, positioning, etc. in his performance assessment. They also aid in control of the exercise.

-- Weapons Firing: when a weapon is fired by an instrumented player, the time of firing, identification of firer, and firer's location are recorded. Similarly, when a simulated round impacts on or near an instrumented player, the time of impact, identification of target, and target's location are recorded. The CIS does a pairing between the firer and the target and will return a result of engagement as being a hit, miss, or kill. The CIS will also tabulate such information as number of rounds of ammunition fired by individual weapon system, type weapon, unit, number of enemy targets of various types hit and killed, current status of forces, etc.

-- Radio Transmissions: the system has the capability to record more than twenty radio nets which will provide a means to monitor transmissions for correct procedures, signal security, electronic warfare actions, etc., as well as a means to check key events.

All data is recorded in the CIS in sufficient detail so that each training element's operations can be examined as a

separate entity down to the individual firing platforms. The data can also be aggregated to produce battalion level statistics to assist in overall unit assessment. The use of equipment such as MILES devices further allows examination of support elements in that a firing platform may be disabled by a controller's key and unable to fire. The controller may return the platform to action only when the proper maintenance or supply functions have been completed, thus forcing the real-time play of these activities. [Ref. 10: p. 27]

B. ADVANTAGES OF THE NATIONAL TRAINING CENTER

It is obvious that the instrumentation at the NTC provides a significant improvement over evaluations done at a normal training post. In addition to the instrumentation, there are other major advantages such as the trained cadre of observers/controllers who are assigned to the units down to platoon level, and the dedicated opposing force (OPFOR) personnel. The cadre of O/C's offer a degree of consistency and confidence of replication of the exercises that could never be attained at a unit's home station. The OPFOR also provides a degree of consistency, the realism and needed combat learning that the units being trained require. The instrumentation, cadre of observers/controllers, and dedicated OPFOR offer precisely what the evaluation for performance degradation demands: accuracy, consistency, and

realism. Only under these conditions can the data needed for such an evaluation be reliable.

Many of the performance indicators that need to be measured for the evaluation of performance degradation are already being measured as a unit progresses through its training at the NTC. It would appear that minimal additional resources would be required to provide the needed data for an evaluation of performance degradation as proposed. The prohibitive costs of setting up an NTC environment at home stations, especially in terms of manpower and money, dictates the use of the NTC for such an evaluation. While some disruption may occur to fit such an evaluation into the NTC, it is far outweighed by the unreliability of data and the conclusions of any data analysis accomplished with lesser resources. The importance of discovering, examining, and compensating for performance degradation due to continuous operations must be realized and given the appropriate attention in terms of training and planning considerations.

V. EVALUATING PERFORMANCE AND THE MEASUREMENT OF DEGRADATION

A. OVERVIEW

An overview of the evaluation system is given to outline the procedures for evaluating performance and for measuring performance degradation, after which the details of the system are described. At the outset it must be understood that several years will be required to conduct unit evaluations that will provide sufficient data needed to conduct the statistical analysis being proposed. The type units to be evaluated will fall into one of four categories: light infantry battalions, mechanized infantry battalions, armor heavy task forces, and mechanized infantry task forces. Units will be compared only to units of a similar type when investigating performance degradation.

There are certain requirements that the units must meet before they are allowed to conduct training at the National Training Center. They must, for example, pass the Army Training and Evaluation Program (ARTEP) given at their home stations. They must also have achieved a certain readiness level in terms of equipment serviceability, training, and personnel. These prerequisites are designed to act as a screening device to prevent wasting time and resources on units that are not prepared to conduct training. These prerequisites will also be used to eliminate units from

taking part in the evaluation whose low readiness posture would bias the results of the evaluation and the data analysis.

B. TYPES OF MEASUREMENT SCALES

As mentioned earlier, the data to be collected will either be of a quantitative or a subjective nature. As such, the measurement scales used in scoring during the evaluation are different. Before discussing the differences between the quantitative and subjective data forms and how they will be analyzed, a review of the four types of measurement scales is presented. The first and weakest of the measurement scales is the nominal scale. This scale uses numbers or names for the purpose of categorizing elements or separating them into classes. The number or name is assigned by convention and serves as only a title for the category of observations, such as a one for a head and a zero for a tail for the results of a coin toss.

The ordinal scale is a measurement scale whereby the value of the measurement is used only as a means of arranging the elements being measured. In other words this scale refers to measurements where only comparative relationships between elements are relevant. This would be the case when "greater than", "less than", or "equal to" measurements are appropriate.

The interval scale considers the relative order of the measurements and also the size of the interval between measurements. This scale involves the concept of a unit distance, such as a degree on a thermometer, where the actual numerical value of the temperature is merely a comparison with an arbitrary point called "zero degrees".

The fourth scale, the ratio scale, utilizes the order, interval size, and ratio between two measurements. The only difference between this scale and the interval scale is that the ratio scale has a natural measurement called zero, such as a height, a weight, a distance, or a measurement of time. [Ref. 12: pp. 64-66]

C. ANALYSIS OF QUANTITATIVE DATA

The quantitative performance indicators are measured on a ratio scale. Performance indicators of this type, such as the number of hits, or the amount of ammunition fired, for example, will be analyzed as follows. The data collectors described in Chapter IV will submit the scores to an analysis group who will record the data for later use in determining whether or not degradation has occurred. The analysis group will employ appropriate statistical tests which will be explained later. In order to use such tests as the T-test or Analysis of Variance, the data must be normally distributed and groups of data being compared must have a common variance. Therefore, when sufficient numbers

of a particular type of unit have been evaluated, their scores are pooled and the sample mean and sample variance computed as follows:

$$\bar{x} = 1/n \sum_{i=1}^{n} x_i, \tag{1}$$

$$s^2 = \sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{n-1}, \tag{2}$$

The next step is to check the data for each performance indicator and type unit to see if they are normally distributed. This is accomplished using the Kolmogorov Goodness-of-Fit Test. Appendix F contains an example of the use of this test. If the hypothesis that the data are normally distributed is rejected, appropriate transformations to normalize the data will be investigated. The use of a computerized version of normal probability paper to choose the best transformation may be very helpful in this endeavor. Some transformations and their effects are shown as examples in Figure 1. An example of the use of transformations is given in Appendix F.

Once the data are determined to be normally distributed or after the data are transformed, a test must be conducted to check for homogeneity of variance between the baseline and the continuous operations data for a particular type of unit. An F-test will be used to compare the variances of

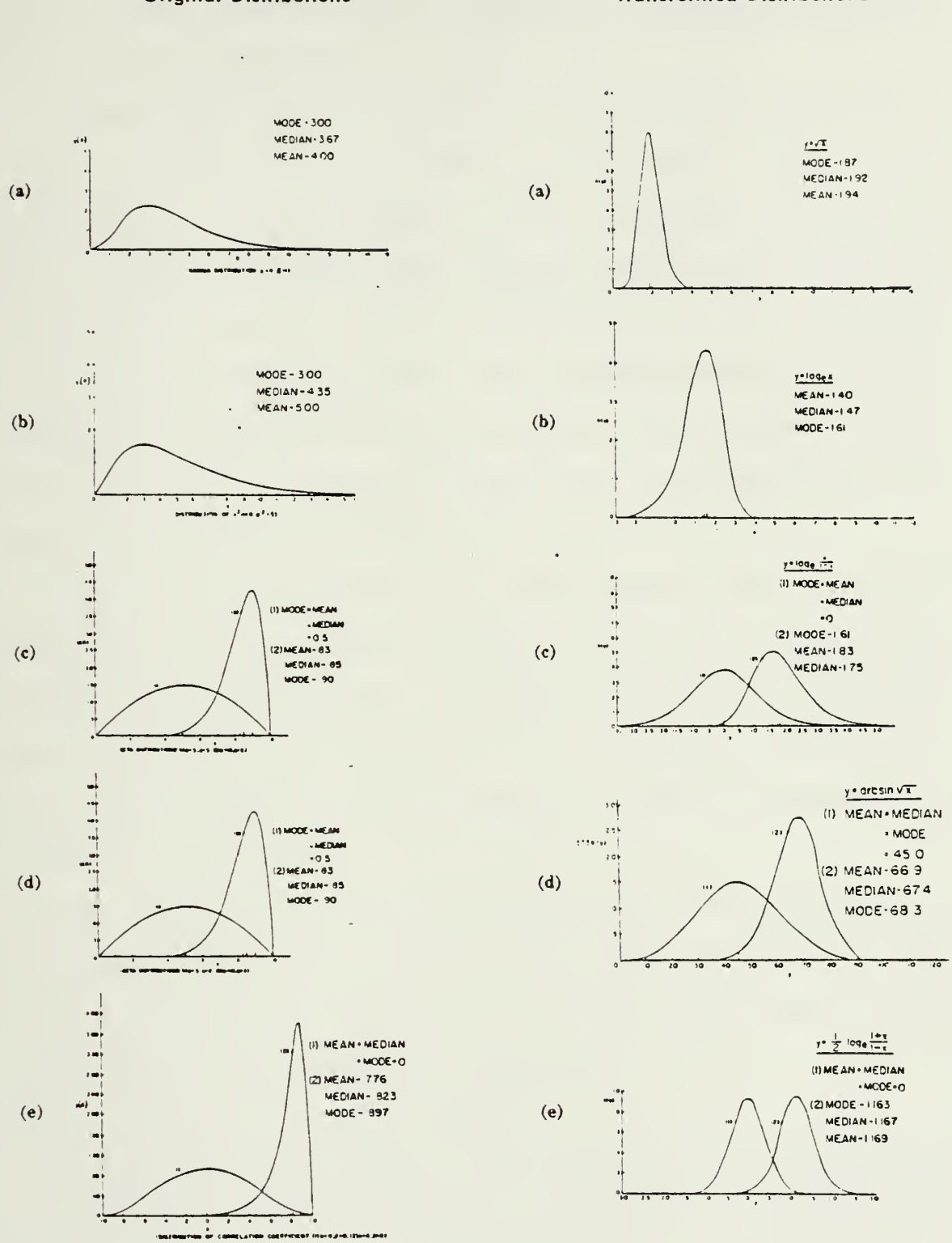


Figure 1. Normalizing Effect of Some Frequently Used Transformations. [Ref. 13: p. 20-3]

the two normal populations. Appendix F contains an example of the use of this test.

If the hypothesis that the two groups of data have a common variance is rejected, a variance stabilizing transformation will be used to attain variance homogeneity. Some of these transformations and their effects are shown as examples in Figure 2. If it is necessary to use a variance stabilizing transformation, the transformed data must be rechecked to insure it is still normally distributed. Often times, however, a variance stabilizing transformation will improve the normality of the data.

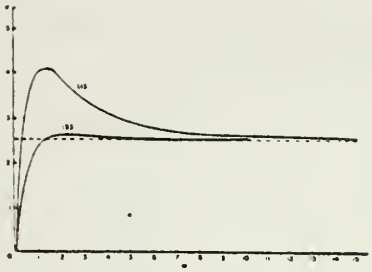
Once the data satisfy the requirements for a normal distribution and a common variance, the T-test will be used to check for degradation. Using the data below, which has been checked for normality and a common variance as explained in Appendix F, an example is given to demonstrate the use of the T-test.

The results of the evaluation of the performance indicator, "Time from attack until objective seized" are given in Table I for baseline and continuous operations. The procedure will test the hypothesis

$H_0: \mu_{CO} = \mu_{BL}$ vs $H_1: \mu_{CO} \neq \mu_{BL}$.

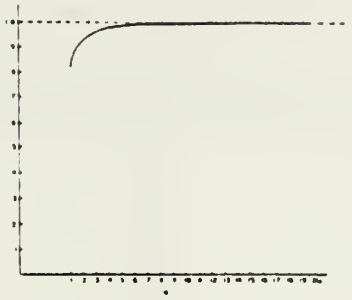
A significance level, α, is chosen for the test (α = .05 is used for this example). The value for $t_{1-\alpha/2}$, for the appropriate degrees of freedom is determined from a t-distribution table. For this example the degrees of freedom

Panel (1)



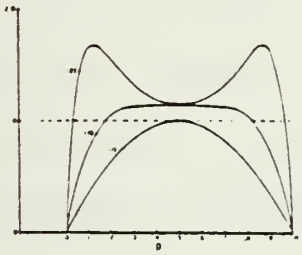
Dependence of the variances of two functions of a sample value X from a Poisson distribution on the Poisson parameter, m. (1) Variance of $\sqrt{X}$; (2) Variance of $\frac{1}{2}\left\{\sqrt{X} + \sqrt{X+1}\right\}$.

Panel (2)



The ratio of the variance of $\log_e s^2$ to its approximate value $2/(n-1)$ in samples of size n from a normal distribution.

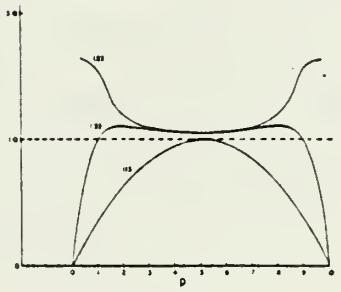
Panel (3)



Dependence of the variances of three functions of a sample proportion X/n on the population proportion p when the *sample size is 10*. (1) 40 Var (X/n); (2) 40 Var $(\sin^{-1}\sqrt{X/n})$; (3) 40 Var (φ_3), where

$$\varphi_3 = \begin{cases} \sin^{-1}\sqrt{1/4\,n} \text{ for } X = 0 \\ \sin^{-1}\sqrt{X/n} \text{ for } X = 1, 2, \ldots, n-1 \\ \sin^{-1}\sqrt{(4\,n-1)/4\,n} \text{ for } X = n \end{cases}$$

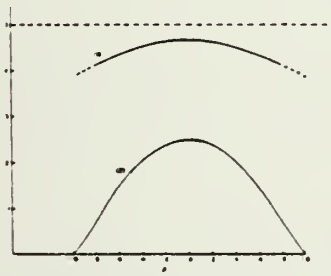
Panel (4)



Dependence of the variances of three functions of a sample proportion X/n on the population proportion p when the *sample size is 20*. (1) 80 Var (X/n); (2) 80 Var $(\sin^{-1}\sqrt{X/n})$; (3) 80 Var (φ_3), where

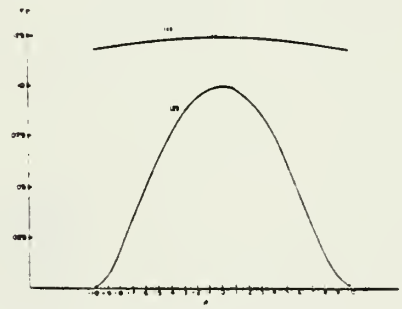
$$\varphi_3 = \begin{cases} \sin^{-1}\sqrt{1/4\,n} \text{ for } X = 0 \\ \sin^{-1}\sqrt{X/n} \text{ for } X = 1, 2, \ldots, n-1 \\ \sin^{-1}\sqrt{(4\,n-1)/4\,n} \text{ for } X = n \end{cases}$$

Panel (5)



Dependence of the variance of the sample correlation coefficient r and of the variance of the transformation $z' = \frac{1}{2}\log\left(\frac{1+r}{1-r}\right)$ on the true correlation coefficient ρ for *sample size* $n = 5$. (1) Variance of z'; (2) Variance of r.

Panel (6)



Dependence of the variance of the sample correlation coefficient r and of the variance of the transformation $z' = \frac{1}{2}\log\left(\frac{1+r}{1-r}\right)$ on the true correlation coefficient ρ for *sample size* $n = 11$. (1) Variance of z'; (2) Variance of r.

Figure 2. Variance-stabilizing Effect of Some Frequently Used Transformations. [Ref. 13: p. 20-7]

Table I. Times From Attack Until Objective Seized (in Minutes)

Baseline	Continuous Operations
172	161
187	157
157	152
152	148
164	158
159	
164	

are $V = n_{BL} + n_{CO} - 2 = 10$. For ten degrees of freedom, $t_{.975} = 2.228$. Computing $\bar{x}_{BL}$ and s_{BL}^2, $\bar{x}_{CO}$ and s_{CO}^2 from the data in Table I yields $\bar{x}_{BL} = 165$, $s_{BL}^2 = 134$, $\bar{x}_{CO} = 155.2$, and $s_{CO}^2 = 26.7$. The pooled unbiased estimate for the standard deviation, σ, is then computed:

$$s_P = \sqrt{\frac{(n_{BL-1})\ s_{BL}^2 + (n_{CO-1})\ s_{CO}^2}{n_{BL} + n_{CO} - 2}} \quad . \tag{3}$$

For the example this is

$$s_P = \sqrt{\frac{6(134) + 4(26.7)}{10}} = \sqrt{91.08} = 9.544.$$

The t-statistic is then defined as

$$T = t_{1-\alpha/2}\ s_P \sqrt{\frac{n_{BL} + n_{CO}}{n_{BL}\ n_{CO}}} \quad . \tag{4}$$

For this example

$$T = (2.228)(9.544)\sqrt{\frac{12}{35}}$$

$$= 21.264(.5855) = 12.45$$

If the difference in the means $|x_{BL} - x_{CO}|$ is greater than T, the decision is that the average scores of the baseline units differ from the average scores of the units under continuous operations; otherwise, the decision is that there is insufficient reason to believe that the average of the baseline units differs from the average of the continuous operations units (i.e., H_O cannot be rejected). Returning to the example,

$$|x_{BL} - x_{CO}| = |165-155.2| = 9.8,$$

which is not larger than T = 12.45. There is no reason to believe therefore, that the baseline units' performance differs from the performance of the units under continuous operations. In other words, no significant degradation was observed for this performance indicator and $H_O: \mu_{CO} = \mu_{BL}$ would not be rejected. If the test results showed that the average score for baseline units differed from the average score for units under continuous operations then it would be said that a difference in performance had occurred and $H_O: \mu_{CO} = \mu_{BL}$ would be rejected. [Ref. 13: p. 3-34]

If H_O is rejected, the mean scores would then be compared to obtain a percent difference in performance. This percentage would be recorded as the percentage that this particular performance indicator differed between the two conditions. This procedure will be described later in the chapter. All quantitative (ratio scale) performance

indicators will be evaluated in this manner to determine those that show a significant difference in performance.

When the four different types of units have been evaluated for a particular performance indicator using the T-test, an ANOVA will be used to further investigate the degradation phenomenon. The ANOVA will reveal whether or not there is a significant difference in the way continuous operations affect the different types of units. This offers the potential to investigate which units might be best suited for certain missions. Before the ANOVA can be used, however, a check for common variance must be made between the groups of data. Because there are more than two types of units being evaluated, Bartlett's Test (a test for comparing more than two normal populations for homogeneity of variance) will be used. An example of the use of Bartlett's Test is contained in Appendix F.

When the data are found to have a homogeneous variance or after the data are transformed so that there is a homogeneous variance, an ANOVA will be used. The following is an example to demonstrate its use. The numbers in Table II represent the mean scores for each type unit for one particular performance indicator. Using the data in Table II and making the necessary computations, the two-way analysis of variance is given in Table III.

Table II. Mean Number of Targets Not Engaged at Least Once.

	TYPE UNIT			
Condition	Light Infantry Battalion (1)	Mechanized Infantry Battalion (2)	Mechanized Infantry Task Force (3)	Armor Heavy Task Force (4)
Baseline	24	16	14	18
Continuous Operations	30	18	18	22

Table III. ANOVA Table for Mean Number of Targets Not Engaged at Least Once.

Source	Degrees of Freedom	Sums of Squares	Mean Squares
Average	1	3200	3200
Condition	1	32	32
Type Unit	3	148	49.33
Residual	3	4	1.33
Total	8	3384	

The F-test is used to test the hypotheses

$$H_0: \mu_{BL} = \mu_{CO}$$

$$H_1: \mu_{BL} \neq \mu_{CO}$$

The computation is as follows for the "condition" source: MSC/MSR = 32/1.33 = 24.1 which exceeds $F_{.95} = 10.12$ with 1 and 3 degrees of freedom. Therefore, the null hypothesis is rejected with $\alpha = .05$. From the same analysis of variance it is possible to test the hypothesis that the effects of continuous operations are equal for the four different type units. Performing the computations, 49.33/1.33 = 37.10 and comparing this result to $F_{.95}$ for 3 and 3 degrees of

freedom, it is evident that 37.10 exceeds 9.27. Therefore, the hypothesis $H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$ is rejected with $\alpha = .05$. Then the alternate hypothesis H_1: at least one of the means is different, is accepted. [Ref. 14: pp. 502-503]

One may wish to further investigate why the units were not all affected in the same way. The light infantry battalion data may be excluded from the analysis and the other type units checked for equal effects, for example. If this subsequent analysis reveals the units are equally affected, more investigation may be warranted for the light infantry battalion for this particular performance indicator. Perhaps a difference occurred because this type unit is not as mobile as the others, or because they lack armor protection. This is used merely as an example of one of the many ways the ANOVA can be used to aid in the analysis process.

D. ANALYSIS OF SUBJECTIVE DATA

The subjective data will be considered in a somewhat different manner. The evaluations of subjective performance indicators are difficult to make on an interval or ratio scale while maintaining the needed consistency between evaluations and between evaluators. A more common approach is to classify subjective performance indicators into categories such as poor, below average, average, above average, and superior; or ineffective, slightly ineffective,

effective, highly effective and extremely effective etc. To aid in consistency and assist the evaluator with his rating task, there are usually descriptors associated with each category. For this evaluation system the categories; poor, below average, average, above average, and superior will be used. The descriptors for these categories are as follows.

The poor rating will be given to signify that the unit or individual being evaluated did not successfully complete the assigned task. This may be due to excessive time taken to perform a task, a violation of doctrinal procedures, failure to achieve a specific requirement, or some other shortcoming warranting an unsatisfactory performance rating. The below average rating will be given to a unit or individual that did not successfully accomplish the assigned mission, but showed some signs of effectiveness during the evaluation. The average rating will be given to the unit or individual that completed the mission or task with marginal success, but performance could still be significantly improved. The rating of above average will signify that the unit or individual successfully completed the assigned mission or task and showed during the evaluation that in some areas they exceeded normal requirements and performance. Finally, the superior rating will be given to those units or individuals who completed all requirements and who performed as well as could be expected of any unit or individual.

The approach for the subjective performance indicators will utilize these categorical ratings with numbers associated with each rating. A poor rating will receive a five, a below average rating a four, an average rating a three, an above average rating a two, and a superior rating a one. The results of the evaluation will be submitted to the analysis group who will review the ratings for a determination of differences in performance. The evaluators will rate the units' performance on a nominal scale, while the analysis group, through use of the associated numbering system, will convert the ratings to an interval scale as described above. Each performance indicator will be evaluated for differences in performances using the same statistical procedures described for the ratio scale data. The approaches differ in that instead of a determination that a difference in performance has occurred and subsequently obtaining a ratio scale measurement of the amount of degradation for the quantitative performance indicators, the subjective performance indicators can be measured only in terms of intervals.

Up to this point the procedures have been explained for data that are normally distributed or can be transformed to fit a normal distribution. If data for a performance indicator is not normally distributed and cannot be transformed to fit a normal distribution, its distribution must be identified. Graphing the data will assist in

identifying the distribution and then the Kolmogorov's Goodness-of-Fit Test will be used to accept or reject the hypothesized distribution. Once the distribution has been identified, appropriate procedures can be developed, based on the distributional assumptions, to analyze the data.

If after attempting to identify the probability distribution of the data for a performance indicator, a distribution cannot be found, nonparametric procedures are required for the analysis of the data. These procedures generally make fewer assumptions about the underlying probability law and thus can be expected to perform quite well over a spectrum of possible distributions. [Ref. 14: p. 508] This greater generality however, is achieved at the price of somewhat reduced discriminating power when assumptions about the distribution and variability of the populations cannot be made. [Ref. 13: p. 3-3] In short, if one is confident that the sample actually came from the assumed probability distribution, parametric tests should be used because they take advantage of the known distribution to give more specific information. If one is not confident of his knowledge of the underlying distribution, then nonparametric tests should be used rather than using parameters that may be incorrect, thereby yielding results that are suspect. Nonparametric tests such as the Squared Ranks Test for Variances to check for homogeneity of variances and the Mann-Whitney Test to check for equal means

between populations would be used to test for whether degradation occurs between baseline and continuous operations. The determination of the amount of degradation is not affected.

E. ANALYSIS OF THE AMOUNT OF DEGRADATION

Once all the performance indicators have been evaluated as described above, the analysis is focused on measurement of the amount of degradation that occurred. For reasons that will soon become evident, the performance indicators will be organized into groups according to the criterion they constitute (See Appendices A through D). This will allow further examination of the performance indicators as a group to determine how much a criterion differed in performance between baseline and continuous operations. Further aggregating these criteria into groups that make up the missions will permit examining the missions for differences in performance.

Up to this point the performance indicators have been examined on an individual basis. The first thing that must be done when the performance indicators are aggregated into groups is that weights must be assigned to each of the performance indicators within each of the criteria, the sum of the weights for a certain criterion being equal to one. These weights are a reflection of a group's consensus as to the relative importance of each performance indicator to its

respective criterion. That group may be the analysis group or another designated body of military experts. The weights will be decided upon before the evaluation begins and will remain fixed. Table IV is a sample format for the analysis group to use as an aid in consolidating the results of an evaluation for a particular criterion for one type of unit.

Table IV. Sample Format for Consolidating Results.

Criterion: Interdiction Target Assignment (Quantitative)

Performance Indicators	WT	Baseline Score	Continuous Operations Score	PD	WTxPD
1. Time to Report Target Location	.2				
2. Percent of Reported Targets not Assigned for Attack	.1				
3. Time From Report of Target Location Until Assigned for Attack	.2				
4. Time From Target Assignment Until Target Attacked	.5				
				TOTAL	

Referring to the T-test results of each of the performance indicators, if it was determined that there was a significant difference between performances, the performance difference, PD, is calculated. As an example, Table V, using the same criterion and performance indicators from Table IV, demonstrates how to evaluate the performance

Table V. Example of Calculating Performance Difference.

Criterion: Interdiction Target Assignment (Quantitative)

Performance Indicators	WT	Baseline Score	Continuous Operations Score	PD	WTxPD
1. Time to Report Target Location	.2	75	100	-.333	-.066
2. Percent of Reported Targets not Assigned for Attack	.1	9.2	8.9	(Not Significant) 0.0	0.0
3. Time From Report of Target Location Until Assigned for Attack	.2	120	110	.083	.017
4. Time From Target Assignment Until Target Attacked	.5	172	212	-.233	-.116
				TOTAL	-.165

indicators and the criterion. Performance Indicator 1, Time to Report Target Location, was determined by the T-test to have a significant difference between baseline and continuous operations performances. Suppose under baseline conditions the mean score for this type unit was 75 seconds and for continuous operations the score was 100 seconds. It should be noted that all performance indicators are constructed so that the higher the score the poorer the performance (i.e., bigger is worse).

The convention for computing the ratio is,

$$PD = \frac{BL - CO}{BL}, \qquad (5)$$

where,

PD is the performance difference,
BL is the baseline score, and
CO is the continuous operations score.

Thus, a positive number indicates a significantly better performance in continuous operations than in baseline. For example, consider performance indicator 1 (PI-1) in Table V; the performance difference, PD, is calculated using equation (5) as (75 - 100)/75 = -0.333, interpreted as PI-1 is degraded by 33.3% in continuous operations. For PI-3 the T-test determined that there was a significant difference in performance and it happened that performance under continuous operations was better than the baseline performance. For example, the mean continuous operations score was 110 seconds and the mean baseline was 120 seconds. Therefore the difference in performance is calculated as (120 - 110)/120 = 0.083, interpreted as an 8.3% improvement in performance for PI-3.

If it was determined that there was no significant difference between baseline and continuous operations for a performance indicator for one type unit, a zero is placed in the performance difference (PD) column for that performance indicator. For this same criterion, the T-test for PI-2 showed no significant difference in performance, so a 0.0 is placed in the PD column.

This procedure is repeated for each performance indicator, for all the criteria. When the procedure is

completed for a criterion, as in Table V, the weights of the performance indicators, multiplied by the difference in performance, will be summed to give the difference in performances for the criterion. As shown in Table V, the summation of the weights multiplied by the difference in performance indicates that there is a difference in performance of -.165 (i.e., this criterion is degraded 16.5% in continuous operations).

The differences in performance for the criteria are then carried forward when the quantitative criteria are aggregated into groups for the purpose of examining differences in performance at the mission level. Table VI is an example of this procedure which is done in the same manner as the aggregation at the criterion level. As seen in Table VI, the -.165 just calculated for the criterion, Interdiction Target Assignment, has been carried forward in the PD column of criterion 4. It is included in the calculations to determine the difference in performance for the mission, which as noted, is -.051 or degraded by 5.1%.

A similar process will be used for the subjective performance indicators, except that the measurement of difference in performances will be on an interval scale. The performance indicators are constructed so that there is no mixing of subjective and quantitative performance indicators within the same criterion, thus avoiding the

problem of adding measurements from two different measurement scales.

Table VI. Example of Aggregation at the Mission Level for Quantitative Data.

Level of Interest: Battalion Command and Control
Mission: Provide Indirect Fire Support (Quantitative)

	Criteria	WT	PD	WTxPD
1.	Fire Support Target Acquisition and Assignment to Direct Fire Battle	.1	0	0.0
2.	Fire Support Effectiveness	.2	.43	0.086
3.	Interdiction Target Acquisition	.1	-.60	-0.060
4.	Interdiction Target Assignment	.1	-.165	-0.017
5.	Interdiction Target Attack Effectiveness	.2	.25	0.050
6.	Counterfire Target Acquisition	.1	0	0.0
7.	Efficient Use of Fire Support Systems	.2	-.55	-0.110
			TOTAL	-0.051

Table VII shows an example of the aggregation of subjective performance indicators at the criterion level and an interval measurement of the difference in performances. As the table indicates there was no significant differences in performance for performance indicators 1, 2, and 4. As was done previously, a zero is placed in the PD column for

Table VII. Example of Aggregation at the Criteria Level for Subjective Data.

Criterion: Locate Opposing Force (Subjective)

Performance Indicators	WT	Baseline Score	Continuous Operations Score	PD	WTxPD
1. Assessment of Movement Techniques	.2	2.1	2.2	(Not Significant) 0.0	0.0
2. Assessment of Use of Cover and Concealment	.2	3.4	3.3	(Not Significant) 0.0	0.0
3. Assessment of Site Selection	.3	1.5	2.3	-0.8	-.24
4. Assessment Use of Visual Signals to Control Movement	.3	3.1	3.0	(Not Significant) 0.0	0.0
				TOTAL	-.24

those performance indicators that did not demonstrate a significant difference in performance. For this example, assume the T-test did determine that there was a significant difference for performance indicator 3. The mean baseline score was 1.5 on the interval scale, while the mean continuous operations score was 2.3. If the same technique is applied as before, the difference in performance would be (1.5 - 2.3)/1.5 = -.53, interpreted as PI-3 was degraded 53% in continuous operations. This procedure is not correct since it is inappropriate to compute percent differences on interval scaled data. The correct method is to conclude that the difference between performance is 1.5 - 2.3 = -0.8,

interpreted as being a decrease in performance of .8 of an interval. The interpretation of this difference is more subjective than when actual percent differences are computed from the ratio scale data. The results are reflected in Table VII and the criterion is shown to be degraded .24 of an interval.

These calculations are shown to emphasize the difference in the measurement scales and their impact on the results. The analyst must keep in mind the difference between the quantitative and subjective data and realize that the numbers are not to be interpreted in the same way.

Recalling the quantitative criteria in Table VI that were aggregated for the purpose of examining performance at the mission level, those missions comprised only of subjective criteria are analyzed in the same manner. Table VIII is an example of this procedure for the scout platoon's mission, Zone Reconnaissance, which is made up only of subjective criteria. As seen, the -.24 calculated for the criterion, Locate Opposing Force, has been carried forward from Table VII and placed in the PD column of criterion 3 in Table VIII. It is included in the calculations to determine the difference in performance for the mission which is 0.299 or interpreted as performance improved in continuous operations by 0.3 of an interval.

Table VIII. Example of Aggregation at the Mission Level for Subjective Data.

Level of Interest: Specialized Platoons
Mission: Zone Reconnaissance (Subjective)

Criteria	WT	PD	WTxPD
1. Plan and Prepare a Zone Reconnaissance	.2	0	(Not Significant) 0.0
2. Deploy Teams	.1	-1.05	-0.105
3. Locate Opposing Force	.2	- .24	-0.048
4. Develop the Situation	.2	1.32	0.264
5. Collection of Terrain Specific Information	.2	.94	0.188
6. Occupy an Assembly Area	.1	0	(Not Significant) 0.0
		TOTAL	0.299

F. MISSION AGGREGATION--MIXED DATA TYPES

Thus far, the aggregation of results has been discussed at the criterion and mission levels when the data have been either all quantitative or all subjective. As mentioned earlier, mixing of the two types of performance indicators that make up a criterion was avoided, thereby presenting no problem relating to mixing measurement scales when aggregating at the criterion level. While examples were given for aggregating at the mission level for those missions constructed of all one type criterion, there are missions of a mixed nature, in which some of the criteria

making up a mission are measured on a ratio scale and some are measured on an interval scale. Table IX is an example of such a mission. Criteria 1 and 2 are subjective criteria with performance differences measured on an interval scale and criteria 3 and 4 are quantitative criteria with performance differences measured on a ratio scale. The procedures for determining the performance differences are the same as described earlier for the subjective and quantitative criteria.

Table IX. Example of Aggregation of a Mixed Mission.

Level of Interest: Rifle Companies
Mission: Deliberate Night Attack (Mixed)

Criteria	WT	PD	WTxPD
1. Prepare to Attack	.2	- .6	- .12
2. Conduct the Attack	.2	-1.2	- .24
		(S) TOTAL	- .36
3. Ability to Acquire and Destroy Targets	.3	- .2	- .06
4. Ability to Seize and Hold Terrain	.3	0	(Not Significant) 0
		(Q) TOTAL	-.06

Aggregating the criteria for this type mission is different however, in that the mission results in two measures of performance differences instead of one. As seen in Table IX, the subjective criteria were degraded -.36 of

an interval in continuous operations and the quantitative criteria were degraded by -.06 or 6% in continuous operations. Independently, these results are interpreted as before, but they must be considered together to evaluate the mission. To do this the analysis group makes a subjective judgment as to how the two results relate to the overall mission. In this example, for instance, the mission is degraded at least 6% since the quantitative criteria are degraded that much and the subjective criteria are also degraded. How much more the mission is degraded depends on the subjective judgment of the analysis group. Either explicitly or implicitly, the group establishes a relationship between a percentage of degradation and an interval of degradation. If, for example, one tenth of an interval equates to .025 or 2.5% on the ratio scale, the subjective result for this mission overall would be that it is degraded an additional 9% for a total degradation of 15%. It must be noted that this is based on a subjective judgment of the relative comparison between percent difference and interval difference.

G. SUMMARY

The analysis methodology for the evaluation system provides for measurement of the amount of performance difference between baseline and sustained operations (with the exception of missions which are an aggregate of

quantitative and subjective criteria). It is essential that any evaluation system which may be implemented assure that all steps of the process described in this chapter be accomplished to assure statistically viable results.

VI. USE OF ANALYSIS RESULTS

When all performance indicators, criteria, and missions have been evaluated and measurements of performance differences noted, the results are of three types.

1. The quantitative performance indicators lead to ratio scale measurements of performance differences at the performance indicator level, the criterion level, and the mission level in that percent differences in performances are derived. These results can be used in different ways.

First, they can be useful in combat simulations to take into account real performance differences for units that have been in continuous operations for a similar time period modelled. For instance, if a performance indicator, such as time to engage a target with indirect fire, has shown through the evaluation to be degraded by thirty percent in continuous operations, this fact can be reflected in the simulation. The thirty percent may translate to a real time difference of one minute; thus in the simulation, responses to calls for fire will be delayed by one minute. Secondly, at the mission level, a result of fifty percent degradation for the hasty attack would mean the effectiveness is cut in half and the game would be so modified to reflect the degradation by reducing the probability of success such as in an aggregated model involving large units.

In general, Table X depicts the relationship that might exist between the different levels of models and the factors measured during the evaluation, particularly for the battalion command and control level.

Table X. Use of Evaluation Factors in Models.

Model	Unit Size	Use of Factors
High Resolution	Battalion an below	Performance Indicators
	Brigade and Division	Criteria
Low Resolution	Theatre Level	Missions

Finally, the results could also be used to indicate the areas where work needs to be done by the units in terms of training. In addition, training methods could be designed and implemented to compensate for noted performance deficiencies due to continuous operations.

2. The interval scaled data is obtained from the subjective performance indicators, criteria, and missions. They are of use in some of the same ways as the ratio scaled data. Even though percentage differences cannot be computed, these indicators, criteria, and missions can point out areas where attention needs to be focused. An analysis group predetermines, for example, that a performance indicator, criterion, or mission with an interval scale change of 0.5 or greater is to be noted and brought to the attention of the unit chain of command as an area in need of

improvement. It also may warrant investigation into these areas by the Army's training centers and schools to find ways of compensating for the unacceptable performance degradation.

3. The subjective judgment is based on the mixture of ratio scaled data and interval scaled data. These judgments are required at the mission level and are made only for those missions comprised of a mixture of quantitative and subjective data. Their use is similar to those in item 2 above. Depending on the confidence placed in the group of military experts making the subjective judgments which link the ratio and interval scaled results, these judgments may be suitable for use in models in the same manner as the quantitative results.

The three types of results offer an advantage that is not usually available to a user of performance data in this type of an evaluation. They offer an audit trail whereby one can find out why a certain number is being used for a parameter. Suppose, for example, interest is generated as to why the mission, Provide Indirect Fire Support, is said to be degraded 5.1%. The criteria for that mission are listed in Table VI along with the recorded performance differences. The criteria in turn, are listed in other tables such as Table V, where the performance indicators are listed with their respective scores and performance differences. Thus, the audit will reveal the causes of the

parameter differences. Identification of the degraded performance indicators and their scores tells not only why a mission was degraded, but allows attention to be focused on those deficient performance indicators in terms of training. By modifying training techniques to improve the performance indicators, enhanced performance at the mission level may be realized.

Some of the uses of the results have been mentioned above, but they are by no means the exclusive uses of the results. The fact that they can be used in computer simulations makes them important in research areas such as the effects of new equipment on tactics, strategies, and doctrine. These factors can also be investigated using the results as parameters in models. It is important to realize however, that caution must be used in applying the results to insure that they are applied appropriately. For example, if the results are of an evaluation conducted at the NTC, they may not be usable as parameters for battle simulations in a jungle or arctic environment. They also may not be suitable to apply to an investigation of units dissimilar to those used in the evaluation. Used appropriately, of course, the results can be employed for a myriad of investigative purposes.

APPENDIX A

Level of Interest: Battalion Command and Control

MISSION: COMMAND AND CONTROL

Criterion: Commander's Perception of Status of Friendly Elements.

Performance Indicators:

-- Proportion of submitted reports of location of elements which are not accurate (Q)

-- Proportion of submitted reports of strength of forces which are not accurate (Q)

-- Proportion of submitted reports of activities of elements which are not accurate (Q)

-- Proportion of required/requested reports of friendly elements status not submitted (Q)

Criterion: Commander's Perception of Status of Threat Forces

Performance Indicators:

-- Proportion of submitted reports of location of threat forces which are not accurate (Q)

-- Proportion of submitted reports of activities of threat forces which are not accurate (Q)

-- Proportion of submitted reports of strength of threat forces which are not accurate (Q)

-- Proportion of required/requested reports of threat force status not submitted (Q)

Criterion: Ability of Commanders to Survive and Time to be Replaced if Necessary.

Performance Indicators:

-- Proportion of commanders assessed as casualties (Q)

-- Time to replace a commander casualty (Q)

-- Time for alternate/jump/main TOC to take over when necessary (Q)

Criterion: Commanders Ability to Use Control Systems

Performance Indicators:

-- Assessment of employment of geographical control measures (S)

-- Assessment of employment of unit SOP's (S)

-- Assessment of adequacy of selected control aids and equipment (S)

Criterion: Validity of Leadership Decisions

Performance Indicators:

-- Assessment of validity of selected leadership decisions (S)

-- Assessment of timeliness of leadership decisions (S)

MISSION: PROVIDE S-1 (PERSONNEL AND ADMINISTRATION) SUPPORT

Criterion: Ability To Provide Administrative And Personnel Support

Performance Indicators:

-- Proportion of required reports not submitted on time (Q)

-- Proportion of requests for personnel actions not submitted on time (Q)

-- Proportion of required and requested reports not submitted (Q)

-- Percent requests for reconstitution not met (Q)

-- Time from initiation of order for replacements until completed (Q)

MISSION: PROVIDE S-2 (INTELLIGENCE) SUPPORT

Criterion: Ability To Acquire And Report Intelligence Information

Performance Indicators:

-- Proportion of targets not detected and reported (Q)

-- Proportion of targets detected but not reported (Q)

-- Time to report targets detected (Q)

-- Time to emplace and dismantle surveillance devices (Q)

Criterion: Ability to Analyze and Disseminate Intelligence Information

Performance Indicators:

-- Time to complete selected processing and analysis tasks (Q)

-- Time to disseminate intelligence information (Q)

-- Percent of targets reported which are false (Q)

Criterion: Effectiveness of Electronic Warfare Systems

Performance Indicators:

-- Assessment of ability to jam threat frequencies (S)

-- Assessment of ability to locate threat electronic warfare systems (S)

-- Assessment of ability to protect EW systems (S)

MISSION: PROVIDE S-3 (OPERATIONS) SUPPORT

Criterion: Ability To Support Commander During Operations

Performance Indicators:

-- Percent of required or requested operations reports not submitted (Q)

-- Percent of required or requested operations reports not submitted on time (Q)

-- Percent of required or requested operations reports submitted that are not accurate (Q)

Criterion: Ability To Run A Tactical Operations Center

-- Assessment of ability to run a tactical operations center (TOC) (S)

-- Assessment of site selection for the TOC (S)

-- Assessment of ability to control operations from the TOC (S)

MISSION: PROVIDE INDIRECT FIRE SUPPORT

Criterion: Fire Support Target Acquisition And Assignment To Direct Fire Battle

Performance Indicators:

-- Number of calls for fire support not answered (Q)

-- Percent of calls for fire support not acknowledged (Q)

-- Time to transmit calls for fire support (Q)

Criterion: Fire Support Effectiveness

Performance Indicators:

-- Threat targets not destroyed per call answered (Q)

-- Threat targets not suppressed per call answered (Q)

-- Time from receipt of call for fire support until execution of attack (Q)

-- Munitions expended by number and type per target destroyed (Q)

Criterion: Interdiction Target Acquisition

Performance Indicators:

-- Number of threat targets not located (Q)

-- Percent of threat targets located but not reported (Q)

-- Percent of target locations that are not accurate (Q)

Criterion: Interdiction Target Assignment

Performance Indicators:

- -- Time to report target location (Q)
- -- Percent of reported targets not assigned for attack (Q)
- -- Time from report of target location until target is assigned for attack (Q)
- -- Time from target assignment until order to attack issued (Q)

Criterion: Interdiction Target Attack Effectiveness

Performance Indicators:

- -- Time from order to attack until attack execution (Q)
- -- Percent of targets assigned for attack not attacked (Q)
- -- Percent of targets attacked but not hit (Q)

Criterion: Counterfire Target Acquisition

Performance Indicators:

- -- Number of targets not located (Q)
- -- Percent of threat targets located but not reported (Q)
- -- Percent of target loactions reported that are not accurate (Q)

Criterion: Efficient Use of Fire Support Systems

Performance Indicators:

- -- Time to respond to calls for fire (Q)
- -- Number of systems firing at targets beyond range capacity (Q)
- -- Number of systems firing at targets out of their section(Q)

MISSION: PROVIDE ENGINEER SUPPORT

Criterion: Ability To Perform Mobility Operations

Performance Indicators:

- -- Times to breach/remove selected obstacles and minefields (Q)
- -- Percent requests for mobility support not met (Q)
- -- Number of requests for mobility support not met (Q)

Criterion: Ability to Perform Countermobility Operations

Performance Indicators:

- -- Times to prepare selected obstacles and minefields (Q)
- -- Number of requests for countermobility operations not met (Q)
- -- Percent of requests for countermobility operations not met (Q)

Criterion: Ability To Perform Survivability Operations

Performance Indicators:

- -- Time to prepare battlefield and facility protection (Q)
- -- Number of requests for support not met (Q)
- -- Percent of requests for support not met (Q)

MISSION: PROVIDE S-4 (LOGISTICS) SUPPORT

Criterion: Ability To Provide Essential Supplies

Performance Indicators:

- -- Percent requests for supplies not met (Q)
- -- Number of required and requested logistics reports not submitted (Q)
- -- Proportion of required and requested logistics reports not delivered on time (Q)
- -- Percent supply requests not delivered on time (Q)

Criterion: Ability To Provide Transportation

Performance Indicators:

- -- Percent requests for transportation not met (Q)
- -- Number of transportation requests not met (Q)
- -- Percent of transportation requests not met on time (Q)

Criterion: Ability To Provide Messing Operations

Performance Indicators:

- -- Assessment of selection of mess hall site (S)
- -- Assessment of ability to provide sufficient and timely food service support (S)

MISSION: PROVIDE COMMUNICATIONS SUPPORT

Criterion: Adequacy Of Communications And Facilities

Performance Indicators:

- -- Assessment of selected aspects of communications facilities (S)
- -- Assessment of ability to operate/repair communications equipment (S)
- -- Assessment of communications site selection (S)

Criterion: Accuracy And Timeliness Of Communications

Performance Indicators:

- -- Mean time for message delivery (Q)
- -- Percent messages with errors and omissions (Q)
- -- Mean number of repititions for each message transmitted (Q)
- -- Percent message clarification requested (Q)
- -- Mean transmission time for counter-electronic warfare purpose (Q)
- -- Percent messages with security violations (Q)

MISSION: PROVIDE MEDICAL SUPPORT

Criterion: Ability to Provide Medical Support

Performance Indicators:

-- Percent requests for medical services not met (Q)

-- Time from casualty occurrence until medical services arrive (Q)

-- Percent of casualties evacuated to higher treatment echelon (Q)

-- Time to evacuate casualty to rear once decision to evacuate has been made (Q)

-- Times to set up and tear down selected medical facilities (Q)

MISSION: PROVIDE MAINTENANCE SUPPORT

Criterion: Ability To Perform Critical Maintenance Services

Performance Indicators:

-- Percent requests for support not met (Q)

-- Times to perform selected maintenance tasks (Q)

-- Percent of repairs evacuated to rear (Q)

-- Times to evacuate selected equipment (Q)

-- Return time to unit of items submitted for repair (Q)

[Ref. 4: pp. 5-1 - 5-53]

APPENDIX B

LEVEL OF INTEREST: RIFLE COMPANIES

MISSION: MOVEMENT TO CONTACT

Criterion: Prepare For The Movement

Performance Indicators:

- -- Assessment of formation selection (S)
- -- Assessment of route of advance selected (S)
- -- Assessment of operations order (OPORD) (S)

Criterion: Conduct The Movement

Performance Indicators:

- -- Assessment of movement techniques' suitability to terrain and expected degree of contact (S)
- -- Assessment of use of cover and concealment (S)
- -- Assessment of use of overwatch positions to support advancing units (S)
- -- Assessment of ability to locate and identify disposition of opposing forces (S)
- -- Assessment of coordination of indirect, machinegun, antitank, and nonorganic fires to support the movement (S)
- -- Reports as to friendly location, nature of terrain, and opposing force situation are submitted as necessary (S)

MISSION: HASTY ATTACK

Criterion: Conduct Hasty Attack

Performance Indicators:

-- Assessment of ability to eliminate opposing force (S)

-- Assessment of ability to determine opposing force strength and disposition (S)

-- If resistance is assessed to be too great to overcome, assessment of request for assistance from higher headquarters (S)

-- Assessment of use of indirect fires (S)

-- Assessment of leader's frag order to accomplish required tasks (S)

-- Assessment of use of cover and concealment (S)

-- Assessment of use of other supporting fires (S)

-- Assessment of ability to consolidate, reorganize and prepare to continue attack once objective is taken (S)

-- Situation reports (SITREPS) submitted as necessary (S)

-- Assessment of movement techniques (S)

Criterion: Ability To Acquire And Destroy Targets

Performance Indicators:

-- Percent threat targets not destroyed (Q)

-- Percent of friendly engagements (Q)

-- Percent of engagements against dead targets (Q)

-- Ammunition expended by quantity and type per target destroyed (Q)

-- Percent threat targets not engaged at least once (Q)

Criterion: Ability To Seize And Hold Terrain

Performance Indicators:

-- Number of friendly casualties (Q)

-- Time from hasty attack initiated until objective seized (Q)

-- Number of enemy survivors (Q)

-- Percent friendly casualties (Q)

-- Percent enemy survivors (Q)

MISSION: DELIBERATE NIGHT ATTACK

Criterion: Prepare To Attack

Performance Indicators:

-- Assessment of commander's scheme of maneuver (S)

-- Assessment of movement techniques selected (S)

-- Assessment of use of terrain (S)

-- Assessment of planned use of fire support (S)

Criterion: Conduct The Attack

Performance Indicators:

-- Assessment of movement to objective (S)

-- Assessment of use of all supporting fires (S)

-- Assessment of responsiveness of supporting fires (S)

-- Use of proper fire and maneuver techniques to eliminate resistance (S)

-- Assessment of ability to secure objective without sustaining excessive casualties and equipment loss (S)

-- Assessment of ability to consolidate, reorganize, and prepare to continue tactical operations (S)

-- SITREPS submitted as necessary (S)

Criterion: Ability To Acquire And Destroy Targets

Performance Indicators:

-- Percent threat targets not destroyed (Q)

-- Percent of friendly engagements (Q)

-- Percent of engagements against dead targets (Q)

-- Ammunition expended by quantity and type per target destroyed (Q)

-- Percent threat targets not engaged at least once (Q)

Criterion: Ability To Seize And Hold Terrain

Performance Indicators:

-- Number of friendly casualties (Q)

-- Percent friendly casualties (Q)

-- Number of enemy survivors (Q)

-- Percent enemy survivors (Q)

-- Time from attack until objective seized (Q)

MISSION: DELAY

Criterion: Occupation Of Battle Position

Performance Indicators:

-- Assessment of adjustment of battle position (BP) after receiving the operation order (S)

-- Assessment of preparation of BP and providing security (S)

-- Assessment of planned use of indirect fires (S)

Criterion: Preparation Of Subsequent Battle Positions

Performance Indicators:

-- Assessment of BP selection, reconnaissance for routes between BP's and preparation of new position (S)

-- Assessment of plan for direct and indirect fires on avenues of approach (S)

-- Assessment of overall fire plan to include target reference point (TRP's), final protective fires (FPF's), and covering routes of march (S)

-- Assessment of reconnaissances for third subsequent BP's (S)

Criterion: Engage Opposing Force

Performance Indicators:

-- Assessment of detection, identification, and reporting of opposing forces (OPFOR) (S)

-- Assessment of engagement of OPFOR from as many BP's as possible with direct fires (S)

-- Assessment of engagement of OPFOR with as much indirect and supporting fires as possible (S)

-- Assessment of ability to shift fires to engage OPFOR (S)

Criterion: Movement To Subsequent Position

Performance Indicators:

-- Assessment of move to new positions over specified routes and occupation of new position (S)

-- Assessment of use of indirect and direct fires to suppress OPFOR as friendly units move (S)

-- Assessment of ability to deny envelopment or bypassing by the OPFOR (S)

-- Assessment of maintenance of contact (S)

-- Assessment of maintenance of control and coordination during movement (S)

Criterion: Ability To Acquire And Destroy Targets

Performance Indicators:

-- Percent threat targets not destroyed (Q)

-- Percent friendly engagements (Q)

-- Percent engagements against dead targets (Q)

-- Ammunition expended by quantity and type per target destroyed (Q)

-- Percent threat targets not engaged at least once (Q)

Criterion: Ability To Hold Terrain

Performance Indicators:

-- Number of friendly casualties (Q)

-- Percent friendly casualties (Q)

-- Number of enemy survivors (Q)

-- Percent enemy survivors (Q)

-- Time required to displace to subsequent positions (Q)

MISSION: DELIBERATE DEFENSE

Criterion: Preparation, Organization, And Plan

Performance Indicators:

-- Assessment of commander's warning order (S)

-- Assessment of plan based on orders from higher headquarters (S)

-- Assessment of reconnaissance (S)

-- Assessment of battle position site selection (S)

Criterion: Occupation Of Fighting/Battle Positions

Performance Indicators:

-- Assessment of use of armor and anti-armor guided missiles in depth (S)

-- Assessment of use of armor and anti-armor guided missiles in mutual support (S)

-- Assessment of position site selection to take advantage of natural or man-made obstacles, cover and concealment (S)

Criterion: Establish Security

Performance Indicators:

-- Assessment of use of observation posts on likely avenues of approach (S)

-- Assessment of plan and use of patrols (S)

-- Assessment of use of sentries (S)

-- Assessment of limited use of radios (S)

-- Assessment of use of early warning devices on likely avenues of approach (S)

-- Assessment of use of challenge and password (S)

-- Assessment of unit alertness along perimeter (S)

Criterion: Prepare Fighting Positions

Performance Indicators:

-- Assessment of selection of primary, alternate and supplementary positions (S)

-- Assessment of planning, preparing and reconnaissance of positions as time permits (S)

-- Assessment of selection for antitank weapon sites (S)

-- Assessment of selection/role for armor (S)

-- Assessment of use of infantry to provide local security for tanks and antitank weapons (S)

-- Assessment of use of camouflage, cover and concealment (S)

-- Assessment of plan for direct and indirect fires to cover avenues of approach, obstacles, and engagement areas (S)

-- Assessment of overall plan for indirect fires to include TRPs, FPFs, illumination, and routes of movement to subsequent battle positions (S)

-- Assessment of preparation of direct fire plan and range cards (S)

-- Assessment of use of obstacles (S)

Criterion: Defend As Opposing Force Approaches Positions

Performance Indicators:

-- Assessment of use of indirect fire (S)

-- Assessment of use of weapons at maximum range (S)

-- Assessment of use of suppressive fires (S)

-- Assessment of use of maximum firepower (S)

-- Assessment of repositioning (S)

-- Assessment of usage of night vision devices (S)

Criterion: Conduct a Counterattack

Performance Indicators:

-- Assessment of concentration of combat power to overwhelm and destroy OPFOR (S)

-- Assessment of maneuver of forces to place effective fires (S)

-- Assessment of use of fire support to stop and destroy opposing forces in penetrated area (S)

Criterion: Consolidation And Reorganization

Performance Indicators:

-- Assessment of counterattacking forces' preparation for another opposing force attack (S)

-- Assessment of reports as necessary and by SOP to include ammunition expenditures, fuel status, vehicles, equipment, and personnel (S)

Criterion: Ability To Acquire And Destroy Targets

Performance Indicators:

-- Threat targets not destroyed (Q)

-- Percent of friendly engagements (Q)

-- Percent of engagements against dead targets (Q)

-- Ammunition expended by quantity and type per target destroyed (Q)

-- Percent threat targets not engaged at least once (Q)

Criterion: Ability To Seize And Hold Terrain

Performance Indicators:

-- Number of friendly casualties (Q)

-- Percent friendly casualties (Q)

-- Number of enemy survivors (Q)

-- Percent enemy survivors (Q)

-- Time to conduct counterattack until objective is seized (Q) [Ref. 6: pp. 7-1-1 - 7-6-3]

APPENDIX C

Level of Interest: Specialized Platoons

SCOUT PLATOON MISSION: SCREEN

Criterion: Plan And Prepare A Screen

Performance Indicators:

-- Assessment of platoon leader's analysis of mission and tasks (S)

-- Assessment of order issued to subordinates to include timeliness (S)

Criterion: Move To The Screen Line

Performance Indicators:

-- Assessment of reconnoitering to screen line and selection of observation post sites (S)

-- Assessment of movement techniques and their consistency with terrain and situation (S)

Criterion: Establish Observation Posts

Performance Indicators:

-- Assessment of observation posts' (OPs) ability to provide overlook of avenues of approach, long range observation, and fields of fire (S)

-- Assessment of use of concealed routes to occupy OPs (S)

-- Once contact is made, assessment of use of indirect fires to slow opposing force (S)

-- Assessment of use of covered and concealed routes to subsequent OPs (S)

-- Assessment of ability to maintain contact with opposing force during movement (S)

Criterion: Reestablish The Screen

Performance Indicators:

-- Assessment of move to assigned areas, occupation of the area, reorganization, and preparation to continue mission (S)

-- Assessment of occupation of OPs on the subsequent screen line (S)

-- Assessment of situation reports to task force (S)

SCOUT PLATOON MISSION: ZONE RECONNAISSANCE

Criterion: Plan And Prepare A Zone Reconnaissance

Performance Indicators:

-- Assessment of platoon leader's analysis of mission and tasks (S)

-- Assessment of order issued to subordinates to include timeliness (S)

Criterion: Deploy Teams

Performance Indicators:

-- Assessment of movement into assigned zone (S)

-- Assessment of reconnoiter of entire zone from one lateral boundary to the other (S)

Criterion: Locate Opposing Force

Performance Indicators:

-- Assessment of movement techniques (S)

-- Assessment of use of cover and concealment (S)

-- Assessment of site selection (S)

-- Assessment of use of visual signals to control movement (S)

Criterion: Develop The Situation

Performance Indicators:

- -- Assessment of platoon deployment and use of fire and maneuver (S)

- -- Assessment of ability to keep commander informed by reporting contacts (S)

Criterion: Collection Of Terrain Specific Information

Performance Indicators:

- -- Given opposing force has withdrawn, assessment of obtaining and reporting information on:

    - -- condition of road network in zone (S)
    - -- cross-country trafficability (S)
    - -- obstacles and removal when possible (S)
    - -- bypasses around obstacles (S)
    - -- fords and water entry/exit points on water obstacles (S)
    - -- other information required by task force order (S)

- -- Assessment of reports given by quickest and most secure means available (S)

Criterion: Occupy An Assembly Area

Performance Indicators:

- -- Assessment of movement to and occupation of an assembly area (S)

Note: Approximately same performance indicators exist for area and route reconnaissances

ANTI-TANK PLATOON MISSION: PROVIDE ANTI-TANK FIRE SUPPORT

Criterion: Place TOW Into Operation

Performance Indicators:

- -- Time taken until the squad/section is prepared for fire, system erected, pre-operational checks completed, and missile loaded (Q)

-- Time taken to prepare a range card IAW TC 7-24, p. B-31 (Q)

Criterion: Deployment Of TOW Weapon Systems

Performance Indicators:

-- TOWs deployed throughout sector in depth (S)

-- TOWs deployed throughout sector in mutual support (S)

-- TOWs deployed to cover most likely armor avenues of approach (S)

-- Fighting positions make maximum use of cover and concealment and fields of fire (S)

Criterion: Engage Multiple Targets

Performance Indicators:

-- Threat targets not destroyed (Q)

-- Percent of friendly engagements (Q)

-- Percent of engagements against dead targets (Q)

-- Number of missiles fired per target destroyed (Q)

-- Percent of threat targets not engaged at least once (Q)

HEAVY MORTAR PLATOON MISSION: PROVIDE INDIRECT FIRE SUPPORT

Criterion: Occupy Primary Position

Performance Indicators:

-- Assessment of platoon's preparation for firing (S)

-- Assessment of platoon's ability to improve the position to include camouflage, all around defense, and individual protection (S)

-- Assessment of platoon's reconnoiter for alternate and supplemental positions (S)

-- Development of plans for operation (S)

Criterion: Fire Registration And Confirm/Adjust A Parallel Sheaf

Performance Indicators:

-- Time taken for platoon to adjust and record firing data corrections (Q)

-- Distance the last adjusting round impacts in meters from the desired registration point (Q)

-- Time taken until parallel sheaf adjustments are completed (Q)

Criterion: Adjust Final Protective Fire

Performance Indicators:

-- Time taken to complete adjustments (Q)

-- Distance the final adjusting round impacts in meters from the target (Q)

Criterion: Prevent Opposing Force Observations Of Friendly Movement (Screen)

Performance Indicators:

-- Time taken to establish an effective screen after the target is identified by the forward observer (Q)

-- Time from initial call for screen until first round impacts (Q)

Criterion: Engage An Area Target

Performance Indicators:

-- Time it takes until platoon initiates fire for effect (FFE) once the target is identified (Q)

-- Distance FFE volleys are from the target area (Q)

Criterion: Shift Fires To An Area Target

Performance Indicators:

-- Time taken until platoon initiates FFE after target identification (Q)

-- Distance FFE is from the target area (Q)

Criterion: Fire Final Protective Fire

Performance Indicators:

-- Time until the first rounds are fired once the command to fire is given (Q)

-- Distance FFE is from the target area (Q)

Criterion: Provide Battlefield Illumination

Performance Indicators:

-- Time taken for platoon to adjust and record firing data (Q)

-- Time from first round fired until illumination of designated area is effective (Q)

Criterion: Conduct Reconnaissance Of A New Position

Performance Indicators:

-- Assessment of reconnoiter of proposed position area and the route to the position (S)

-- Assessment of reconnoiter of alternate and supplemental positions (S)

-- Assessment of development of plan for position occupation (S)

Criterion: Conduct Displacement To New Position

Performance Indicators:

-- Time for first section to move to new position and become ready to fire (Q)

-- Upon notification that the first section is in place, time for the second section to move to new position and become ready to fire (Q) [Ref. 6: pp. 8-36-1 - 8-47-2]

APPENDIX D

Level of Interest: Individual Soldiers

Selected Individuals: General

First Aid Tasks

-- Ability to perform mouth to mouth resuscitation and external heart massage (S)

-- Ability to stop bleeding (arm or leg wound)(S)

-- Ability to identify signs of and treat for shock (S)

-- Ability to splint a fracture (S)

-- Ability to apply first aid measures for burns (S)

-- Ability to apply first aid measures for heat injuries (S)

-- Ability to apply first aid for wet or cold injuries (S)

Nuclear, Biological, And Chemical Tasks

-- Ability to perform operator's maintenance on an M17 series protective mask (S)

-- Ability to exchange filters on an M17 series protective mask (S)

-- Ability to put on and wear a protective mask (S)

-- Ability to put on and wear protective clothing (S)

-- Ability to decontaminate self (S)

-- Ability to decontaminate individual equipment (S)

-- Ability to identify a chemical agent using ABC-M8 detector paper (S)

-- Ability to demonstrate visual, vocal, and sound alarms for an NBC attack (S)

-- Ability to satisfy personal needs in a chemical environment (S)

-- Ability to protect self against a nuclear hazard (S)

-- Ability to administer antidote to a nerve-agent casualty (S)

-- Ability to administer antidote to blood-agent casualty (S)

-- Ability to apply artificial respiration to a chemical-agent casualty (S)

-- Ability to recognize and protect self against a chemical/biological hazard (S)

Basic Individual Techniques

-- Ability to move as a member of a fire team (S)

-- Ability to move under direct fire (S)

-- Ability to react to indirect fire (S)

-- Ability to react to flares (S)

-- Ability to move over, through, or around obstacles (S)

-- Ability to estimate range (S)

-- Ability to select temporary battlefield positions (S)

-- Ability to construct individual fighting positions (S)

-- Ability to use visual signals to control dismounted movement (S)

Camouflage, Cover And Concealment Tasks

-- Ability to camouflage/conceal self and individual equipment (S)

-- Ability to camouflage/conceal equipment (S)

-- Ability to camouflage/conceal defensive positions (S)

-- Ability to clear fields of fire (S)

Security And Intelligence Tasks

-- Ability to use challenge and password (S)

-- Ability to process known or suspected enemy personnel (S)

-- Ability to collect/report information - SALUTE (S)

-- Ability to conduct day and night surveillance without the aid of electronic devices (S)

-- Abililty to engage enemy armor weak points (S)

-- Ability to identify opposing force armored vehicles (S)

-- Ability to identify opposing force weapons and equipment (S)

Land Navigation Tasks

-- Ability to identify terrain features on the map (S)

-- Ability to determine grid coordinates of a point on a map using the military grid reference system (S)

-- Ability to determine azimuths using a coordinate scale and protractor (S)

-- Ability to convert azimuths (magnetic or grid) (S)

-- Ability to determine a magnetic azimuth using a compass (S)

-- Ability to determine direction using field expedient methods (S)

Night Vision Device Tasks

-- Ability to perform operator maintenance on an AN/PVS-2 (S)

-- Ability to conduct surveillance using an AN/PVS-2 (S)

M16A1 Rifle Tasks

-- Ability to perform operator maintenance on an M16A1 rifle, magazine and ammunition (S)

-- Ability to load, reduce a stoppage, and clear an M16A1 rifle (S)

-- Ability to battlesight zero an M16A1 rifle (S)

-- Ability to qualify with the M16A1 rifle (S)

-- Ability to use limited visibility firing techniques with the M16A1 rifle (S)

-- Ability to mount/dismount AN/PVS-2 on M16A1 rifle (S)

-- Ability to zero AN/PVS-2 when mounted on M16A1 rifle (S)

-- Ability to engage a target with a rifle using AN/PVS-2 (S)

Light Anti-Tank Weapon (LAW) Tasks

-- Ability to prepare an M72A2 LAW for firing; restore M72A2 LAW to carrying configuration (S)

-- Ability to engage targets with an M72A2 LAW (S)

-- Ability to apply immediate action to correct a malfunction on an M72A2 LAW (S)

Hand Grenade Tasks

-- Abililty to perform safety checks on hand grenades (S)

-- Ability to engage enemy targets with hand grenades (S)

-- Ability to identify and employ hand grenades (S)

Mine Tasks

-- Ability to install and fire/recover an M18A1 claymore mine (S)

-- Ability to install the M18A1 claymore with tripwires (S)

-- Ability to disarm the M18A1 claymore (with tripwires) (S)

-- Ability to install the M21 metallic antitank (AT) mine (S)

-- Ability to disarm the M21 metallic antitank (AT) mine (S)

-- Ability to install the M16A1 bounding antipersonnel mine (w/w/o tripwires) (S)

-- Ability to disarm the m16A1 bounding antipersonnel mine (w/w/o tripwires) (S)

-- Ability to locate mines by visual means (S)

-- Ability to locate mines by probing (S)

-- Ability to neutralize enemy mines (S)

Selected Individuals: M203 Grenadier

M203 Grenadier Tasks

-- Ability to perform operator maintenance on M203 grenade launcher and ammunition (S)

-- Ability to load, unload, and clear the M203 (S)

-- Ability to zero an M203 (S)

-- Ability to engage targets with an M203 and apply immediate action to reduce a stoppage (S)

-- Ability to use limited visibility firing techniques with the M203 (S)

Selected Individuals: Dragon Gunner

Dragon Gunners Tasks

-- Ability to conduct a preoperational inspection of the Dragon tracker and round (S)

-- Ability to prepare the Dragon for firing (S)

-- Ability to demonstrate correct Dragon firing positions (S)

-- Ability to determine if a target is engageable (S)

-- Ability to prepare an antiarmor range card (Dragon) (S)

-- Ability to perform immediate action procedures for a Dragon misfire (S)

-- Ability to construct a fighting position (Dragon) (S)

-- Ability to perform emergency destruction procedures (S)

Selected Individuals: M60 Machinegunner

M60 Machinegunner Tasks

-- Ability to perform operator maintenance on an M60 machinegun and ammunition (S)

-- Ability to operate an M60 machinegun (S)

-- Ability to fire the M60 MG for familiarization (S)

-- Ability to construct an M60 MG position (S)

-- Ability to lay M60 MG using field expedients (S)

-- Ability to field zero an M60 MG (S)

-- Ability to prepare a range card for an M60 MG (S)

-- Ability to zero an M60 MG on 10-meter range (S)

-- Ability to qualify with an M60 MG (S)

-- Ability to mount/dismount an AN/PVS-2 on an M60 MG (S)

-- Ability to zero an AN/PVS-2 to an M60 MG (S)

-- Ability to maintain a caliber .45 pistol (S)

-- Ability to engage targets with a caliber .45 pistol (S)

Selected Individuals: Radiotelephone Operator

Radiotelephone Operator Tasks

-- Ability to perform operator preventive maintenance on telephone sets (TA-312/PT or TA-1/PT) (S)

-- Ability to install telephone set (TA-312/PT or TA-1/PT) (S)

-- Ability to perform operator maintenance on radio sets: AN/PRC-77 or AN/VRC-64 (S)

-- Ability to operate radio set AN/PRC-77 or AN/PRC-25 (S)

-- Ability to prepare radio set AN/VRC-64 for operation (S)

-- Ability to perform operator maintenance on radio sets AN/VRC-46 or AN/VRC-47 (S)

-- Ability to prepare tactical FM radios (AN/VRC-46 or AN/VRC-47) for operation (S)

-- Ability to use an automated CEOI (S)

-- Ability to use KAL-61B 1400 numerical code to authenticate transmissions and encrypt/decrypt numbers and grid zone letters (S)

-- Ability to encode and decode messages using a KTC-600 tactical operations code (S)

-- Ability to establish and enter or leave a radio net (S)

-- Ability to transmit and receive a radio message (S)

-- Ability to prepare/operate switchboard SB-993 (S)

-- Ability to install and operate communications security equipment TSEC/KY-8 using RT-524/VRC (S)

-- Ability to install and operate speech security equipment TSEC/KY-38 using RT-841/RCC-77 (S)

-- Ability to install radio set control group AN/GRA-39 (S)

-- Ability to operate radio set control group AN/GRA-39 (S)

Selected Individuals: Squad Gunner

Squad Gunner Tasks (Mechanized Units Only)

-- Ability to perform operator maintenance on a caliber .50 M2 HB machinegun and ammunition (S)

-- Ability to target/zero a caliber.50 MG (S)

-- Ability to load, reduce a stoppage, unload, and clear a caliber.50 MG (S)

-- Ability to engage targets with a caliber .50 MG (S)

-- Ability to set headspace and timing on a caliber .50 MG (S)

-- Ability to mount/dismount An/TVS-2 sight on caliber .50 MG (S)

-- Ability to boresight AN/TVS-2 to caliber .50 MG (S)

Selected Individuals: Wheeled-Vehicle Driver

Wheeled-Vehicle Driver Tasks

-- Ability to drive a wheeled vehicle cross-country (S)

-- Ability to drive a wheeled vehicle on roads, in vehicle parks, and in built up areas (S)

-- Ability to drive a wheeled vehicle using blackout drive (S)

-- Ability to start a wheeled vehicle engine using auxiliary power, (M151, M715, and M561) (S)

-- Ability to perform ESC inspection on a wheeled vehicle (S)

-- Ability to maintain required TAMMS records on a wheeled vehicle (S)

-- Ability to perform operator maintenance on a wheeled vehicle (S)

-- Ability to recover a wheeled vehicle (S)

Selected Individuals: Tracked-Vehicle Driver

Tracked-Vehicle Driver Tasks

-- Ability to drive an APC cross-country (S)

-- Ability to drive an APC on roads, in vehicle parks, and in built-up areas (S)

-- Ability to drive an APC with night vision-devices, infrared equipment and blackout drive (S)

-- Ability to operate an APC in water (S)

-- Ability to start the APC engine using auxiliary power (S)

-- Ability to perform a tracked vehicle ESC inspection (S)

-- Ability to maintain required TAMMS records on a tracked vehicle (S)

-- Ability to perform operator maintenance on an APC (S)

-- Ability to recover a tracked vehicle using field expedients (S)

Selected Individuals: TOW Crewman

TOW Crewman Tasks

-- Ability to assemble the TOW launcher (S)

-- Ability to perform operator maintenance on TOW weapons system (S)

-- Ability to conduct a system self test and preoperational inspection (S)

-- Ability to load, arm, and unload an encased missile (S)

-- Ability to perform immediate action procedures for a misfire (S)

-- Ability to determine if a target can be engaged (S)

-- Abililty to camouflage/conceal TOW position (S)

-- Ability to prepare an antiarmor range card (TOW) (S)

-- Ability to maintain a caliber .45 pistol (S)

-- Ability to engage targets with a caliber .45 pistol (S)

Selected Individuals: Scouts

Scout Tasks

-- Ability to perform operator maintenance on an M60 MG and ammunition (S)

-- Ability to operate an M60 MG (S)

-- Ability to zero an M60 MG on a 10-meter range (S)

-- Ability to qualify with an M60 MG (S)

-- Ability to mount/dismount an AN/PVS-2 on an M60 MG (S)

-- Ability to zero an AN/PVS-2 to an M60 MG (S)

-- Ability to perform operator maintenance on radio sets AN/VRC-46 or AN/VRC-47 (S)

-- Ability to prepare tactical FM radios for operation (S)

-- Ability to use an automated CEOI (S)

-- Ability to use KAL-61B 1400 numerical code to authenticate transmissions and encrypt/decrypt numbers and letters (S)

-- Ability to encode and decode messages using a KTC-600 tactical operations code (S)

-- Ability to establish and enter or leave a radio net (S)

-- Ability to transmit and receive a radio message (S)

-- Ability to install and operate communications security equipment TSEC/KY-8 using RT-524/VRC (S)

-- Ability to install and operate speech security equipment TSEC/KY-38 using 841/PRC-77 (S)

-- Ability to locate a target by shift from a known point (S)

-- Ability to call for/adjust indirect fire [Ref. 7: pp. 3-117 - 3-163] (S)

Selected Individuals: 4.2-inch Mortar Crewman

4.2-inch Mortar Crewman Tasks

-- Ability to ground mount a 4.2-inch mortar (S)

-- Ability to boresight a 4.2-inch mortar (S)

-- Ability to perform safety checks on a 4.2-inch mortar (S)

-- Ability to prepare 4.2-inch mortar ammunition for firing (S)

-- Ability to perform operator maintenance on a 4.2-inch mortar and equipment (S)

-- Abililty to remove a misfire from a 4.2-inch mortar (ground mounted) (S)

-- Ability to refer sight and realign aiming posts for a 4.2-inch mortar (S)

-- Ability to reciprocally lay a 4.2-inch mortar using an M2 aiming circle and place out aiming posts (S)

-- Ability to manipulate a 4.2-inch mortar for traversing fire (S)

-- Ability to place a carrier mounted 4.2-inch mortar into action (mechanized units only) (S)

-- Ability to remove a misfire from a carrier mounted 4.2-inch mortar (mechanized units only) (S) [Ref. 15: pp. 3-117 - 3-163]

APPENDIX E:

SAMPLE SCENARIO

EVENT #	DAY	TIME	WHO	EVENT	WHERE	OPFOR ACTION	DESIRED RESULTS	REMARKS
1	1	0400	BN CDR + STAFF	ISSUE OPORD	BN HQ's		Begin planning, troop leading procedures, issue orders	Evaluators link up with units
2	1	0500	BN	Deployment readiness evaluation	BN Area		EDRE SOPs evaluated for contents, completeness and accuracy	
3	1	0500	BN S2/S3	OPSEC Eval	BN Area and Assembly Area			
4	1	0500-UTC	BN	Maintenance Eval	BN Motor Pool and Assembly Area		Vehicles/Equipment Ready to Deploy	
5	1	0500-UTC	BN	PAC Eval	BN Area and Assembly Area			
6	1	0700	BN	Occupy Assembly Area	IAW OPORD	Local Patrols	Conduct coord/ Liaison conduct recon, request intel	

7	1	1200	BN	Conduct Movement to cont-act (MTC)	In Zone	Delay/Light resistance MG and small arms firing	React to contact by rapidly returning fire, deploying, reporting and devel-oping situation maintain commo w/ higher
8	1	1600	BN	Conduct Hasty Attack	OBJ 1A + 1B	Reinforced PLT defend and withdraw, leave 5 OPFOR as POW, (two requiring medical treat-ment)	BN Retains momentum and pursues attack. Fire spt coordinated Combat power concen-trated at critical PT + enemy over-whelmed w/o excess-ive casualties. Re-quest aerial medevac consolidate + reorg-anize + prepares to continue MTC
9	1	1600	BN	Breach a wire obstacle	Vic OBJ 1A	Cover by Fire	Suppress OPFOR fire, attempt to bypass, organize breaching tms, mark lanes, evac casualties
10	1	NLT 1730	BN	Secure Hasty Atk obj-ectives	OBJ 1A + 1B	Same as event 8	Same as event 8
11	1	2000	BN CDR	Issue deliber-ate atk FRAGO	OBJ 1A		Issue orders reorganize as required establish patrols and security plan

12	1	2300	BN	Patrol	In Zone Forward of Positions	Observe, Resist if pressed	Maintain contact with enemy forces Collect EEI	Free play
13	2	0300	BN	Conduct deliber-ate night attack	In Zone to secure OBJ 2	Offer strong resistance,then withdraw	Cross LD on time covrd fire spt w/ scheme of maneuver Eng fwd to neutral-ize obstacles. strict comsec units assigned missions providing mutual spt.	Cont-inual EW jam-ming
14	2	0300-	Heavy Mortar PLT	Conduct mortar eval	In Posi-tion		Appropriate fire spt	
15	2	NLT 0600	BN	Secure Deliber-ate atk obj	OBJ 2	Same as event 13	Same as event 13	
16	2	0600-UTC	BN	Consol-idation + reorg.	OBJ 2		Consolidate, estab-lish security,resupply as needed	
17	2	1200	BN CDR	Issue FRAGO for delay	OBJ 2	Prepare to move against delay positions	Begin planning, troop leading procedures. Issue orders coord for required support	
18	2	1500	BN	Conduct Delay	IAW OPORD	Atk ea. delay position forcing friendly units to fall back	Movement to successive delay positions avoid-ing decisive engagement	

19	2	1500	Anti Tank Platoon	Conduct AT Eval	IAW OPORD	Same as event 18	Provide Adequate AT spt.
20	2	1800	BN CDR	Issue deliberate Defense FRAGO	As directed by BN CDR	Cease advance	Begin planning, troop leading procedures. Issue orders + readjust as needed BN security force + covering force dispatched. Plan patrols Begin work on DEF positions.
21	2	1800	BN	Conduct Deliberate Defense	VIC BN Security	Patrol	Units continue prep of defense. Wire laid
22	2	1800-UTC	BN	Construct Wire obstacle + Install Hasty Mine Field	IAW OPORD		Blocks likely enemy avenue of approach Covered by fire. Security Est. during construction. Barrier materials/mines Requested + delivered by SPT. PLT. use of eng.
23	2	2100	OPFOR	Surrender	FEBA	2 deserters ask for asylum	Evacuate/report
24	2,3	2100 day 2 -0900 day 3	BN	Defense continues	FEBA	Continuous probes attempt to take POWs	

25	3	0900	OPFOR	Enemy Squad sighted in Mopp 4	FEBA	SQD blunders into DEF PSNS	Report BN orders Mopp 3	
26	3	1000	BN	NBC Atk	FEBA		Sound alarm, go to Mopp 4, submit NBC 1 report survey team conduct OPNS leading to submission of NBC 2 report request DECON assistance	Evaluators tell survey team they have detected GB
27	3	1000	BN	Mass Casualty Evac	In Zone		Recovery OPNS initiated	30 casualties Identified by evaluators as a result of NBC attack
28	3	1000-UTC	BN	Decontamination	TBD		Company Designated vacates DEF positions + decon rapidly + efficiently. BN reallocates + shifts forces as required. Survey teams resurvey reassume original defensive positions.	Give survey team negative readings

29	4	0600	OPFOR	Conduct deliber-ate atk	FEBA	Stage forceful atk, then with-draw	Hold positions, call for fire spt, concentrate fire power on main enemy thrust.
30	4	0800	BN	Conduct counter attack	FEBA	Offer slight resistance + withdraw	overcome enemy resistance, ad-vance to desig-nated limit of advance
31	4	1200-UTC	BN	M16/60 + 50 cal sampling	Ranges		

APPENDIX F

This appendix contains examples of the application of three statistical tests to compare assumed distributions and assess homogeneity of variance for sample data populations.

I. Examples of the Use of the Kolmogorov Goodness-of-Fit Test and Use of a Transformation.

This test is used to make a comparison between the actual and the theoretical distribution of a sample of data. The procedure is as follows:

1. Let $F(x)$ be the completely specified theoretical cumulative distribution function under the null hypothesis.

2. Let $S_n(x)$ be the sample cumulative distribution function based on n observations.

3. Let $x_{(1)} < x_{(2)} < \ldots x_{(n)}$ be the order statistics. The computation of the Kolmogorov statistic is most easily done in the following stages. Compute

$$D^+ = \max_{1 \leq j \leq n} F(x_{(j)}) - S_n(x_{(j-1)})$$

$$D^- = \max_{1 \leq j \leq n} S_n(x_{(j)}) - F(x_{(j)})$$

$$D = \max(D^+, D^-)$$

4. If, for the chosen significance level, the test statistic is greater than or equal to the critical value found in the tables, the null hypothesis, H_o: $F = F_o$ is rejected.

The data in Table XI are the times, measured in seconds, twenty units took to transmit calls for fire support. Kolmogorov's Test is used on these data to check for

Table XI. Observed Times for Units to Call for Fire Support (in seconds)

Observed Times to Transmit Calls for Fire, x, (in secs)	Observed Frequency	Observed Cumulative Frequency	Relative Cumulative Frequency $S_n(x)$	Expected Relative Cumulative Frequency F(x)	D^+	D^-
24	1	1	.05	.140	.140	-.090
26	1	2	.10	.166	.116	-.066
32	2	4	.20	.271	.171	-.071
33	2	6	.30	.291	.091	.009
34	3	9	.45	.312	.012	.138
35	2	11	.55	.334	-.116	.216
36	1	12	.60	.356	-.194	.244
37	1	13	.65	.374	-.226	.276
39	1	14	.70	.421	-.229	.279
49	2	16	.80	.652	-.048	.148
58	1	17	.85	.821	.021	.029
64	1	18	.90	.900	.050	.000
72	1	19	.95	.960	.060	-.010
91	1	20	1.00	.998	.048	.002

normality. The sample average, $\bar{x}$, and the sample variance, s^2, are used as estimates for the population mean and variance. The sample average, $\bar{x}$, = 42.35 and the sample variance, s^2, = 286.24. For any observed x,

$$S_n(x) = r/n \quad \text{where,}$$

r = number of observations less than or equal to x.
n = number of observations.

$F(x) = N((x-\bar{x})/s)$, N being the normal distribution function.

From Table XI it is seen that

$D = MAX\ (D^+, D^-) = .279$. To test the hypothesis,

$$H_o: F(x) = N(42.35, 286.24)$$

Stephens' modification is used, i.e.,

$$T = D(\sqrt{k} - .01 + .85/\sqrt{k}),$$

where k is the number of distinct values observed. [Ref. 16: pp. 730-737]

For these data the modified test statistic is

$$T = .279(\sqrt{14} - .01 + .85/\sqrt{14}) = 1.10.$$

The critical value in the table is 1.035 for a significance level of .01. Since $1.10 > 1.035$ the null hypothesis, H_o: $F(x) = N(42.35, 286.24)$ is rejected at this significance level.

Since the data cannot be assumed to be of a normal distribution, a transformation is sought to normalize the data so statistical tests, such as the T-test and an analysis of variance, may be utilized. The natural logarithmic transformation is used for this example and the transformed data appear in Table XII.

Table XII. Transformed Times for Units to Call for Fire Support (in seconds)

Transformed Times to Transmit Calls For Fire, y=ln(x) (in seconds)	Observed Frequency	Observed Cumulative Frequency	Relative Cumulative Frequency $S_n(x)$	Expected Relative Cumulative Frequency F(x)	D^+	D^-
3.18	1	1	.05	.071	.071	-.021
3.26	1	2	.10	.109	.059	-.009
3.47	2	4	.20	.268	.168	-.068
3.50	2	6	.30	.300	.100	.000
3.53	3	9	.45	.330	.030	.120
3.55	2	11	.55	.352	-.098	.198
3.58	1	12	.60	.386	-.164	.214
3.61	1	13	.65	.421	-.179	.229
3.66	1	14	.70	.476	-.174	.224
3.89	2	16	.80	.732	.032	.068
4.06	1	17	.85	.866	.066	-.016
4.16	1	18	.90	.921	.071	-.021
4.28	1	19	.95	.961	.061	-.011
4.51	1	20	1.00	.992	.045	.008

The transformed sample average, $\bar{y}$ = 3.68 and the sample standard deviation, s_y = .341. From Table XII it is seen that D = .229. Therefore the modified test statistic is computed as,

$T = .229 (\sqrt{14} - .01 + .85/\sqrt{14}) = .904.$

Since .904 < 1.035 the null hypotheses,

H_o: $F(y) = N(3.68, 0.341)$ is not rejected at the .01 significance level. The assumption can now be made that the transformed data is normally distributed and therefore satisfies the normality requirement of statistical tests such as the T-test and analysis of variance.

II. Example of the Use of the F-test to Check for Common Variance Between Two Normal Populations.

Table XIII. Observed Times to Prepare TOW Range Cards (in seconds)

Population A	Population B
526	414
406	430
499	419
627	453
585	504
459	459
415	337
460	598
506	425
450	438
624	456
506	385

To test the hypothesis H_o: $\sigma_1^2 = \sigma_2^2$ vs H_1: $\sigma_1^2 \neq \sigma_2^2$ first choose a level of significance such as $\alpha = .05$. Look up $F_{1-\alpha/2}$ for $(n_a - 1, n_b - 1)$ degrees of freedom and $F_{1-\alpha/2}$

for (n_b-1, n_a-1) degrees of freedom. For the data in Table XIII above $F_{.975}(11,11) = 3.48$. Next compute s_a^2 and s_b^2 from the observations yielding $s_a^2 = 5545$ and $s_b^2 = 4073$. Computing $F = s_a^2/s_b^2$ gives $F = 5545/4073 = 1.36$.

If $F > F_{1-\alpha/2}(n_a-1, n_b-1)$ or $F < 1/F_{1-\alpha/2}(n_b-1, n_a-1)$ the null hypothesis would be rejected. In this case $F_{.975}(11,11) = 3.48$ and $1/F_{.975}(11,11) = 0.29$. Since F is not larger than 3.48 and is not smaller than 0.29 the null hypothesis is not rejected. [Ref. 13: pp. 4-8 - 4-9]

III. Example of the Use of Bartlett's Test to Check for Common Variances of Several Normal Populations.

To test the hypothesis H_o: $\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \sigma_4^2$ versus H_1: at least one variance is not the same, the test statistic is

$$\chi^2 = 2.3026\left[(\log_{10} s^2)\sum_{i=1}^{4}(n_i-1) - \sum_{i=1}^{4}(n_i-1)\log_{10} s_i^2\right]$$

which has approximately a chi-square distribution with 3 degrees of freedom. If $\chi^2 \geq \chi^2_{(1-\alpha)(3)}$, the null hypothesis would be rejected.

As an example, the data set in Table XIV will be used. The pooled estimate of the variance $s^2 = 3437/20 = 171.85$ Using the above formula,

$$\chi^2 = (2.3026)(44.7030 - 43.48358) = 2.80784$$

It can be seen that $2.81 < \chi^2_{.95(3)} = 7.81$ and thus the hypothesis of homogeneous variances may not be rejected at the 5 percent significance level. [Ref 17: pp. 127-129]

Table XIV. Observed Times to Breach a Minefield (in minutes)

TYPE UNIT			
1	2	3	4
48	42	33	78
49	39	42	69
67	51	46	60
75	57	47	52
53	75	50	63
33			45
			50
			35

From these data the results in Table XV are obtained.

Table XV. ANOVA Table for Times to Breach a Minefield.

Source	Degrees of Freedom	Sum of Squares	Mean Squares
1	5	1113.0	222.6
2	4	820.8	205.2
3	4	173.2	43.3
4	7	1330.0	190.0
Total	20	3437.0	

LIST OF REFERENCES

1. Human Resources Research Organization Technical Report 69-8, The Effects of Sleep Deprivation on Performance Over a 48-Hour Period, by Eugene H. Drucker, Dennis Cannon, and J. Roger Ware, May 1969.

2. Department of the Army, U.S. Army Intelligence Threat Analysis Center, Soviet Army Operations, April 1978.

3. Human Resources Research Organization Professional Paper 7-70, HUMRRO Studies in Continuous Operations, by Donald F. Haggard, March 1970.

4. ORI, Inc. Technical Report (ORI-TR-2071) Independent Evaluation Plan for a Nuclear, Biological, and Chemical Force Development Test and Experimentation, by William P. Hannah and David Lees, 2 August 1982.

5. U.S. Army Research Institute for the Behavioral and Social Sciences Technical Report, Research on Systems Analytic Approaches To Unit Evaluation: specification of Performance Variables and Measures for ES-Based ARTEP, by George R. Wheaton, Eugene Johnson, III, and Larry J. Dondero, July 1981.

6. Department of the Army, Army Training and Evaluation Program 71-2, Army Training and Evaluation Program for Mechanized Infantry/Tank Task Force, 17 June 1977.

7. Department of the Army, FM 7-11B1 Soldier's Manual, MOS 11B1, Infantryman (Skill Level 1), September 1982.

8. Department of the Army, FM 21-2 Soldier's Manual of Common Tasks Skill Level 1, December 1982.

9. Department of the Army, Army Regulation No. 350-50, National Training Center (NTC), 15 March 1980.

10. Furman, J.S. and Wampler, R.L., A Methodology for the Evaluation of Unit Tactical Proficiency at the National Training Center, M.S. Thesis, Naval Postgraduate School, Monterey, California, March 1982.

11. Fuller, David, W. Maj, USA, Take Home Package Coordinator, Training Analysis and Feedback Division,

The National Training Center, Fort Irwin, California. Telephone Interview, 10 November 1983.

12. Conover, W.J., Practical Nonparametric Statistics, 2nd Edition, John Wiley & Sons, Inc., 1980.

13. Natrella, M.G., Experimental Statistics, Handbook 91, U.S. Department of Commerce, National Bureau of Standards, 1 August 1963.

14. Larson, Harold, J., Introduction to Probability Theory and Statistical Inference, 3rd Edition, John Wiley & Sons, Inc., 1982.

15. Department of the Army, FM 7-11C1, Soldier's Manual, MOS 11C1, Indirect Fire Infantryman (Skill Level 1), September 1981.

16. Stephens, M.A., EDF Statistics for Goodness of Fit and Some Comparisons, Journal of American Statistical Association, September, 1974.

17. Ostle, Bernard, and Richard W. Mensing, Statistics in Research, 3rd Edition, Iowa State University Press, 1975.

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